DEVELOPMENT OF NATIONAL STANDARDS FOR WASTE DISPOSAL IN SOILS

Sponsored by

Central Pollution Control Board
Ministry of Environment and Forest
Govt. of India, New Delhi

Conducted by

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May, 1991

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ACKNOWLEDGEMENTS

The Project team would like to express its sincere acknowledgement to :

- National Bureau of Soil Survey & Land Use Planning, Nagpur
- Industrial Toxicology Research Centre, Lucknow
- National Environmental Engineering Research Institute, Nagpur
- All India Soil and Land Use Survey, Nagpur
- Embassies/High Commissions of various countries (listed in Section 3)
- Overseas Organisations (listed in Section 3)

We also acknowledge the continued support provided by Dr. R.K. Pachauri, Director, Tata Energy Research Institute, New Delhi.

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BACKGROUND

"Man is a mistake. We could call him nature's greatest mistake. He spares no cruelty, no evil, no ruthlessness in achieving his vile aims. He is so greedy that he has virtually wiped out all other forms of life and his greed still shows no sign of abating".

Someone expressed this opinion in an article regarding environment and its damage by human race. Pollution is a an "illegitimate child" of human genius or in other words, it is an unwanted twin sister of fast growing technology. Scientists and technocrats never intended to create it while developing technology-to add more luxury in our everyday life. But as soon as technology is transferred to commercial sector from laboratories, all other aspects of production are usually ignored except the commercial viability. There is no need to scan the history of last hundred years which has witnessed major damage to nature than ever before. Many so called revolutions like industrial revolution, green revolution, cultural revolution etc. did not take care of biodiversity and natural resources in a healthy manner. Most of the inventions/innovations lacked long term planning. Problems were identified, their solutions discovered but these solutions were partial only as they did not took care of anticipated problems. All the pollution caused due to various types of waste is result of knowingly or unknowingly but avoided anticipated problems. Since we started living in community and building houses during evolutionary period, probably we were more detached emotionally from nature than any other

member of animal kingdom. Presently, every source of life (air, water and land)is polluted or damaged.

India has a landmass of 329 million hectares with tremendous ecogeographic diversity. Almost all types of habitats available in the world are found in India. Highly regarded environmentalist Dr. T. N. Khoshoo stated that India has 45,000 species of plants - nearly 15,000 of these are flowering plants. The Indian region is the Centre of Diversity of 152 economic species of which the important ones are rice, sugarcane, coix, minor millets, brassicas, rice bean, cowpea and tropical legumes, cucumber, egg plant, tropical fruits, banana, citrus, mango, bread fruit, coconut, cardamoms, nutmeg, tea, tree, cotton, jute, tuberous crops, dioscorea, alocasias, amorphophalus, colocasia, pepper, ginger, rhododendrons, jasmines, bamboos, ornamental orchids, betel leaf, betelnut, etc. It is a secondary centre for grain amaranths, hevea, oil palm, red pepper, soyabean, etc.

As far as animal wealth is concerned, there are 65,000 species, out of which there are about 50,000 species of insects, 340 mammals, and 2000 fish. Among domestic animals there is excellent diversity in buffalo, cattle, goat, sheep, pig, poultry, horses, ponies, camel, mithun and yak. The productivity of these animals by western standards is very low.

<u>Importance of Biological Diversity</u>: Conservation of biological resources is expected to make important contributions to social and economic development e.g. greater agricultural productivity through countering pests, pathogens and bringing about climatic

and edaphic changes; by utilizing still unknown species for industry and medicine, and developing new products for national and international markets thereby creating job opportunities and generated income. Strictly from the human point of view, the most important contribution of the earth's biota is to maintain the ability of the ecosystem to provide essential life support like the fixation of solar energy, protection of soil, regulation of water flow and recycling of nutrients. Any disturbance that exceeds the natural regenerative capacity of the biological systems will impair the ability of the system to perform these functions.

E.F. schumacher (1973) described a beautiful relationship between nature - human and plants.

We can say that man's management of the land must be primarily oriented towards three goals - health, beauty and permanence. The fourth goal - the only one accepted by the experts - productivity, will then be attained almost as a by-product. The crude materialistic view sees agriculture as "essentially directed towards food-production." A wider view sees agriculture as having to fulfill at least three tasks:

* to keep man in touch with living nature, of which he is and remains a highly vulnerable part;
* to humanise and ennoble man's wider habitat; and
* to bring forth the foodstuffs and other materials which are needed for a becoming life.

I do not believe that a civilisation which recognizes only the third of these tasks and which pursues it with such ruthlessness and violence that the other two tasks are not merely neglected but systematically counteracted, has any chance of long-term survival.

Apart from being used for many constructive and destructive uses, soil has also been used as a sink for any type of waste without considering the further effects of its impact on land capability. Following table provides an outline of land capability classification.

Table 1.1 : Land-capability Classification

LAND CLASS	LAND-CAPABILITY AND USE PRECAUTIONS	PRIMARY USES	SECONDARY USES
I.	Excellent land, flat, well drained. Suited to agriculture with no special precautions other than good farming practice.	Agriculture	Recreation Wildlife Pasture
II.	Good land with minor limitations such as slight slope, sandy soils, or poor drainage. Suited to agriculture with precautions such as contour farming, strip cropping, drainage etc.	Agriculture Pasture	Recreation Wildlife
III.	Moderately good land with important limitations caused by soil, slope, or drainage, Requires long rotation with soil-building crops, contouring or terracing, strip cropping or drainage, etc.	Agriculture Pasture Watershed	Recreation Wildlife Urban-industrial
IV.	Fair land with severe limitations caused by soil, slope, or drainage. Suited only to occasional or limited cultivation.	Pasture Tree crops Agriculture Urban-industrial	Recreation Wildlife Watershed
	Group II. Lands Not Suitable for Cultivation		
V.	Land suited to forestry or grazing without special precautions other than normal good management	Forestry Range Watershed	Recreation Wildlife

VI.	Suited to forestry or grazing with minor limitations caused by danger from erosion, shallow soils, etc. Requires careful management	Forestry Range Watershed Forestry Range Watershed Urban-industrial	Recreation Wildlife Recreation Wildlife
VII.	Suited to grazing or forestry with major limitations caused by slope, low rainfall, soil, etc. Use must be limited, and extreme care taken.	Watershed Recreation Wildlife Forestry Range Urban-industrial	
VIII.	Unsuited to grazing or forestry because of absence of soil, steep slopes, extreme dryness of wetness	Recreation Wildlife Watershed Urban-industrial	

Source : U.S. Soil Conservation Service, 1952 (modified version)

Urban and industrial use of land involves lot of indiscriminate use, of land for waste disposal causing enormous land pollution. So far, there is not proper soil quality criteria is existing in our country. In other words, suitability of land for its use is yet to be intensively studied and decided. For example, even for agricultural use, land suitability plan is not in practice though agriculture is the largest industry in India.

Because the nation's agricultural soils constitute one of its most valuable resources, long-term productivity of such soils must be maintained or enhanced. At the same time, proper and responsible use of soils for disposal of certain solid waste materials can recycle valuable nutrients, improve the physical properties of soils, and provide a cost-effective method for waste disposal with financial benefits to the urban sector. Likewise, some solid wastes, primarily composted organic materials and fly ash aid in reclamation of land disturbed or impaired by surface

mining. These reclamation efforts may increase the land's agricultural productivity beyond its premining capability. Organic solid wastes can substitute in the urban sector for commercial products in landscaping (e.g. of highways, parks and homes).

The long-term potential hazards of solid disposal on agricultural and urban land are from those waste constituents that will accumulate in soil and are not readily recycled through plants, primarily heavy metals and stable toxic organics. For domestic sewage sludges, garbage, and agricultural processing wastes, annual application rates that satisfy the nitrogen or phosphorus requirements of agricultural or horticultural crops (1-10 t/ha) will prevent accumulation of these materials, and regulations as presently formulated for cadmium and polychlorinated biphenyls (PCB) can control total accumulation in a particular soil. Disposal of more contaminated solid wastes on land may require the use of dedicated sites with controlled drainage and more extensive monitoring. The waste disposal history of all sites should be maintained as guidance for long-term land use change.

The following table summarizes the general beneficial and potentially harmful properties of solid waste materials that are commonly applied to land. The major benefits are organic matter and nutrients (particularly nitrogen and phosphorus), whereas the major long-term hazards are heavy metal and toxic organic accumulations. Some materials, particularly water treatment lime sludge, offer beneficial liming effects and many of the wastes

provide varying amounts of trace nutrients. Many of the properties given in table are rate variable. Digested sewage sludges contribute significant amounts of organic matter only at high application rates, and the total amounts of heavy metals

Table 1.2: Relative Beneficial and Harmful Properties of Selected Solid Waste Materials

Solid Waste	Properties: Beneficial: Organic Matter	N	P	K	Lime Equivalent	Harmful: Heavy Metals	Toxic Organics	Pathogens	Salt	Acidity
Digested Sewage Sludge	M	H	H	L	M	V	L	M	M	M
Composted Sewage Sludge	H	M	M	L	M	L	L	L	L	L
Processing Wastes	H	M	M	M	V	L	L	L	V	V
Industrial Wastes, Organic	H	V	L	L	L	L	H	L	L	M
Industrial Waste, Inorganic	L	V	V	V	V	V	L	L	H	V
Fly Ash	L	L	V	L	H	L	L	L	H	L
Water Treatment lime Sludge	L	L	L	L	H	L	L	L	M	L
Basic slags	L	L	V	V	H	M	L	L	M	L

H,M,L = high, medium and low; V = variable
Source : Dasmann, 1984.

added to soil are more important in heavy metal uptake by plants than the concentrations of those metals in sludges. Although salt accumulation can be a problem for long-term land application of some solid wastes in climatic regions with low net percolation rates, it has not been a problem in more humid regions.

Most of developed countries are using land in three ways to dispose the waste i.e.

- Land application (to the land surface)
- Land fill (very near the surface)
- Land burial (near surface or deep)

Land disposal of solid wastes by chemical plants consists of either dumping the waste in piles on the ground or burying it. All the major types of process solid wastes are sometimes disposed of by this method, including sludges, tars, off-quality product, filter residues, and fly ash.

Wastes dumped on the ground are principally dry chemicals, filter residues, and heavy sludges. They are generally inert and insoluble inorganic chemicals which do not generate odors on decomposition or pollute surface and ground waters through leaching of pollutants. Other effects of some solid wastes (such as emission of noxious gases, dusting, or esthetic problems) may prevent disposal by this method. A large percentage of the solid wastes dumped on the ground are sludges dredged from settling ponds or lagoons.

The disposal of liquid digested sludge on open land surfaces is quite common among smaller wastewater treatment plants. In England, the disposal of liquid sludge to farmland is very popular and in the arid and semiarid parts of the United states, the reclamation of water from municipal sewage is becoming increasingly recognized as an important water conservation measure. Liquid digested sludge and supernatant have been applied to lands for final disposal to fertilize grass or agricultural crops for soil conditioning.

Digestion, aerobic or anaerobic, is almost always required before spreading liquid sludge on land. Sludge is distributed on the land and processed in a variety of ways; it may injected into

the subsoil under pressure or pumped or gravity fed through a pipeline to agricultural fields or land to be reclaimed. A common technique is disposal directly to the land by spraying from tank wagons. Design considerations and process variables involved are: proximity of surface waters and distance to groundwater table, toxic constituents of the sludge, nutritional value of the sludge, availability of disposal sites, transportation costs, suitability of soil for sludge disposal, nature of any esthetic nuisance, effects on vegetation, application rates, atmospheric and climatic conditions, and method of sludge application. Design criteria can only be developed through the use of fairly large demonstration sites and extensive time-involving studies are required. The effects of land disposal on crops and ground and surface waters is of paramount importance.

Construction of the scientific landfill essentially entails the excavation of a cavity of compacted clay. The cell is situated partially above ground and partially below ground and has specific internal slope specifications. Following compaction and sloping of the clay, the cavity is lined with a synthetic liner. The use of both compacted clay and the synthetic liner provides the facility with "double liner" protection. Following installation, the liner is covered with a 2-ft layer of compacted clay, which serves the dual function of acting as both a third liner and a protective barrier for the synthetic liner. Finally sump pipes are installed in accordance with internal slope specifications. The sump pipes are 3-ft diameter, perforated concrete pipes, which stand on end and are built up as the

landfill is filled. The sumps function as both a monitoring stations for the landfill and a means for withdrawing liquid from the interior of the landfill. Upon completion, the landfill is sealed with a 4-ft layer of compacted clay. Top soil is placed on top of the clay cap, the area is graded and sloped, and an appropriate vegetative cover is seeded to prevent erosion and provide aesthetic value. The landfill is constructed partially above ground, and the final cap is sloped to facilitate the movement of surface water laterally rather than vertically through the landfill. This will reduce the amount of water reaching the interior of the landfill.

Land burial is to be differentiated from land application (to he land surface) or landfill (very near the surface). Land burial is adaptable to those hazardous materials that require permanent disposal. Disposal is accomplished by either near-surface or deep burial. In near-surface the material is deposited either directly into the ground or is deposited in stainless steel tanks or concrete lined pits beneath the ground. The standard procedures for deep burial are disposal in salt mines or hard bedrock, or in shale formations by using hydraulic fracturing. Hydraulic fracturing is not covered here but is covered under deep well disposal.

In land burial the waste is transported to the selected site, where it is prepared for final burial. Transportation of the wastes to the hurial site can be accomplished in three ways: by common carriers with the waste packaged along with ordinary shipments of wastes,,by contract carriers that handle only the

hazardous materials to be buried but collect from various sources, or ;by private carriers that transport their own wastes from the point of origin to the burial site.

Either solid or liquid wastes can be received at the burial site. To reduce the mobility of the wastes before burial all liquid wastes should be converted to a solid form. This requires that special solidification equipment be located at the burial site. Coupled with this special solidification equipment heavy equipment for excavation and lifting and special monitoring instruments and stations will also be required.

At the present time near-surface burial of both radioactive and chemical wastes is being conducted at several Atomic Fnergy Commission (AFC) and commercially operated burial sites. These wastes are buried in unlined trenches approximately 20 feet in depth. The trenches are filled to within 2 to 5 feet of the surface and are covered with either asphalt or soils and vegetation to reduce infiltration of water. Radioactive wastes are stored in either liquid or solid form in steel tanks enclosed in concrete.

Pilot plant studies have been conducted for deep burial in salt formations and hard bedrock. These wastes would be buried approximately 1,000 to 1,500 feet beneath the ground in unlined tunnels. The wastes are lowered into these tunnels by means of a central access shaft. After the filling operation is complete in a tunnel, it is sealed off by backfilling with salt and using a positive seal, for example, concrete.

The processes described earlier regarding various types of waste disposal in soil are being followed in developed countries and are result of tremendous research work.

2. OBJECTIVES

To develop national standards for waste disposal in soil requires various types of information regarding soils and wastes therefore following objectives were originated:

1. to collect intensive information on soils of India (detailed characterization).
2. to collect intensive information of various types of wastes produced in India (special emphasis on chemistry of waste)
3. to collect information regarding soil-waste interaction reactions in India and abroad.
4. to collect information regarding standards/guidelines followed in different countries for waste disposal in soils
5. to analyse the collected information for Indian conditions (soil, waste, climate, water table, land use pattern etc.)
6. to develop national standards for waste disposal in soils (if possible).

3. METHODOLOGY

We have followed an approach of information collection through correspondence, manual and on-line literature search and visits to specific organisations and institutes.

Correspondence:

International

Embassies/high commissions of the following countries were contacted for providing us the addresses of the institutes in the area of 'environmental protection', 'wastes disposal' and 'soil science'.

Afghanistan	Indonesia	Poland
Argentina	Iran	Portugal
Austria	Iraq	Romania
Australia	Ireland	Saudi Arabia
Belgium	Italy	Singapore
Brazil	Japan	Spain
Bulgaria	Jordan	Sweden
Canada	Kenya	Switzerland
Chile	Korea-D.P.R.	Tanzania
China	Peoples Republic of Korea	Thailand
Colombia	Malaysia	Turkey
Czechoslovakia	Mexico	Uganda
Denmark	Nepal	U.K.
Egypt	Netherlands	U.S.A.
Finland	New Zealand	Venezuela
France	Nigeria	Yugoslavia
German Democratic Republic	Norway	Zambia
Federal Republic Germany	Pakistan	Zimbabwe
Greece	Panama	
Hungary	Philippines	

Following organisations/institutes/ministries etc. were requested to provide detailed information on soi , waste and soil-waste interactions.

Direction Gen. des Rel.
Bruxelles BELGIUM

Ministers de la Region Wallonne
Namur BELGIUM

Vlaamse Gemeenschap
Brussels BELGIUM

Department for the Environment
Wellington NEW ZEALAND

Department of Scientific and
Industrial Research
Lower Hutt NEW ZEALAND

Organisations of Environment and Conservation
Wellington NEW ZEALAND

Jugoslovenski savet za zastitu i
unapredenje covekove sredine
Beograd YUGOSLAVIA

Ministry of Environment
SINGAPORE - 0922

Ministry of Environment
Copenhagen K DENMARK

Secretaria De Agricultura
Y Recursos Hidraulicos
Piso MEXICO

Secretaria De Energia, Minas E Industria
Paraestatal
Piso MEXICO

Consejo Nacional De Ciencia Y Tecnologia
Universitaria MEXICO

Empresa Brasileira de Pesquisa
Agropecuaria-EMBRAPA

Centro Nacional de Recursos Geneticos (CENARGEN)
Brasilia BRASIL

Secretaria Especial do Meio
Brasil

Ministerio da Agricultura
Brasilia BRASIL

Universidade Federal do Rio Grande do Sul
Porto Alegre BRASIL

Department of the Environment
Dublin I IRELAND

Environment Research Unit
Dublin 4 IRELAND

Department of Agriculture
Dublin 2 IRELAND

Federal Department of the Interior
Bern SWITZERLAND

Eidgenossische Forschungsanstalt fur
obst,-Wein - und Gartenbau
Wadenswil SWITZERLAND

Mount Makulu Central Research Station
Chilanga, ZAMBIA

National Council for Scientific Research
Lusaka ZAMBIA

Ministry of Science, Technology & the Envrionment
Kuala Lumpur MALAYSIA

Dept. of Agriculture
Soils Management Branch
Kuala Lumpur, MALAYSIA

Department of Soil Science
Selangor MALAYSIA

Environmental Management Bureau
Department of Environment & Natural Resources
Quezon City PHILIPPINES

Bureau of Soils and Water Management
Manila PHILIPPINES

Ministero dell'Ambiente
ROMA ITALY

Ministry of Science, Technology and Energy
BANGKOK

Ministry of Agriculture and Coopertives
BANGKOK Thailand

Agricultural Land Reform Office
Ministry of Agriculture and cooperatives
BANGKOK Thailand

Dept. of Indian Affairs & Northern Development
Ottawa CANADA

Environment Council of Alberta
Edmonton CANADA

Ministry of Environment
Public Affairs & Communications Branch
Victoria CANADA

Dept. of the Environment
CANADA

Dept. of Environment & Lands
St. John's CANADA

Dept. of Environment & Public Safety
CANADA

Environmental Protection Office
Toronto CANADA

Dept. of Renewable Resources
Yellowknife CANADA

Communications
Ottawa CANADA

Envionment Protection Headquarters
Hull CANADA

The State Pollution Control Authority
Oslo 1 NORWAY

Ministry of Agriculture
Oslo 1 NORWAY

Centre for Soil & Environmental
Research (JORDFORSK)
aas-NLH NORWAY

Norwegian Institute of Land Inventory (NIJOS)
N-1430 Aas NORWAY

Norwegian Forest Research Institute (NISK)
N-1432 aas-NLH NORWAY

Department of Biotechnological Sciences
Agricultural University of Norway
Aas-NLH NORWAY

Ministry of Agriculture
Helsinki FINLAND

Soil and Water Ltd.
Helsinki FINLAND

Secretaria General de Medio Ambiente
MADRID ESPAIN

Instituto Nacional de Investigacion Agrarias (INIA)
MADRID ESPAIN

Ministry of Environment
Oslo 1 NORWAY

Ministry of Environment Protection
Kampala Uganda

P.O Box 3
Entebba Uganda

Office of Environment
Seoul Korea

National Institute of Environment Research
Seoul Korea

Ministry of Agriculture
Nairobi Kenya

The Conservator of Forests
Nairobi Kenya

Ministry of Arid & Wastelands
Nairobi Kenya

National Institute for Public Health &
Environment Protection
Bilthoven Netherlands

Ministry of Public Health, Physical
Planning and Environment
Den Haag Netherlands

RIZA,
Lelystad Netherlands

International Institute for Land
Reclamation and Improvement
Wageningen Netherlands

Center for Environmental Research
Austin, Texas 78767 U.S.A

Cornell University
Center for Environmental Research
Ithaca, N.Y. 14853 U.S.A

Environmental Protection Agency
Washington, D.C. 20460 U.S.A

Soil Conservation Service
Department of Agriculture
Washington, D.C. 20013

Department of the Environment
London SW1P 3EB U.K.

Countryside Commission
Gloucestershire GL50 3RA
U.K.

Royal Commission on Environment Pollution
London SW1P 3BL U.K.

The Soil Association
Bristol U.K.

Office of the National Environment Board (ONEB)
Thanon Rama VI Bangkok 10400

Bangkok Metropolitan Administration (BMA)
Thanon Dinso Bangkok 10200

Thailand Institute of Scientific and
Technological Research (TISTR)
Bang Khen Bangkok 10900

Municipal Branch
Edmonton, Alberta Canada T5K 2J6

Soils Protection Branch
Alberta Canada

Ministerstwo Ochrony Skodowiska I Zasobow Naturalnych
Wawelska 52/54 POland

Instytut Ochrony Srodowiska
Jrycza 5/11 POland

Ketua Pengarah
Unit Tenaga Nuklear
Kajang SELANGOR DARUL EHSAN

L'Agence Pour La Qualite De L'Air
Paris-La-Defense France

Le Ministere De L'Environnement
Direction de la prevention des pollutions
France

Ministere De L'Environnement
Direction de la preention des pollutions
France

Ministere de L'Environnement
Paris France

IFREMER
Paris France

I.S.T.P.M. (Institut Scientifique et
Technique des Peches Maritimes)
Nantes France

Ministere de L'Environnement
Direction de la prevention des pollutions
France

L 'Agence Nationale pour la Recuperation
et l'Eliminaion des Dechets
Angers Cedex France

Bureau Parisien
Paris France

Ministere de L'Environnement
Delegation a la qualite de la vie
Neuilly sur Seine Cedex France

Union Nationale Des Centres Permanents
D'Initiation a L'Environnement (C.P.I.E)
Paris France

Federation Nationale des Conseils
D'Architecture D'Urbanisme Et
D'Environnement (C.A.U.E.)
Paris France

Mouvement Nationale de Lutte Pour
L'Environnement
Pantin Cedex France

Fonds D'Intervention Pour Les Rapaces
Saint Cloud France

Association Nationale de Protection
des Salmonides Truite-Ombre-Saumon
Alfortville France

Ministere de L'Equipement, Du Logement De
L'Amenagement du Territoire et des Transports
Paris France

Science du sol (Department)
INRA-Centre de Recherches de Versailles
France

Association Francaise Pour
L'Etude des Eaux
Paris France

Ministry of Agriculture
Dar Es Salaam Tanzania

Ministry of Lands, Housing and Natural Resources
Dar Es Salaam Tanzania

Instituto Nacional De Los Recursos Naturales (Inderena)
Bogota - Colombia South America

Natural Resources Board
Causeway, Harare Zimbabwe

Chemistry and Soil Research Institute
Causeway, Harare Zimbabwe

Ministry of Natural Resources & Environment
Causeway, Harare Zimbabwe

Ministry of Environment & Energy
Stockholm Sweden

National Environmental Protection Board
Solna Sweden

The Eqyptian Environment Affairs Agecy (EEAA)
Zamalek, Cairo (Egypt)

T.C. Basbakanlik Cevre Mustesarligi
Ankara, Turkey

Committee for Environmental Protection
Sofia, Bulgaria

IPPD "N. Pushkarov"
Sofia, Bulgaria

Agricultural Research Institute
Pakistan

Soil Fertility Survey and Soil
Testing Institute
Pakistan

Soil Survey of Pakistan
Lahore, Pakistan

National Institute of Science &
Technology
Philippines

1' ANRED
FRANCE

France Nature Environnement
PARIS, FRANCE

Ministry of Oil
Baghdad, Iraq

Ministerio de Relaciones Exteriores y Culto
ARGENTINA

Instituto Nacional de Tecnologia Agropecuaria (INTA)
ARGENTINA

Subsecretaria de Argicultura, Ganaderia y Pesca
ARGENTINA

Fundacion para la Educacion, la
Ciencia y la Cultura (FECIC)
ARGENTINA

Asociacion Amigos del Suelo
ARGENTINA

Asociacion Amigos de la Tierra
ARGENTINA

Fundacion para la Defensa de Ambiente
ARGENTINA

Bundesministerium fur Forschung und Technologie
(Federal Ministry for Research & Technology)
Germany

Umweltbundesamt (UBA)
(Federal Environmental Agency)
Germany

Central Unit on the Environment
Department of the Environment
London SW1P 3PY

Nature Conservancy Council
London

Friends of the Earth
London N1 7JQ

National Rivers Authority
London SE1 7TL

Institute of Waste Management
London

National Environmental Management Council
Tanzania

Ministry of Housing, Physycal planning
and Environment
The Netherlands

Rijksinstituut voor Volksgezondheid en Milieuhygiene
The Netherlands

Soil and Water Research Institute
Cairo, Egypt

Egyptian Authority of Environment Affairs
Cairo, Egypt

National Environment Mangement Council
Tanzania

Ministerre De L'Environnement
France

A.N.R.E.D
France

Pelican's Operation (FNE)
France

I.N.S.A
France

Kornyezetvedelmi Miniszterium
(Ministry of Environment Protection)
Hungary

Foldmuvelesugyi Miniszterium
(Ministry of Agriculture)
Hungary

Noveny- es Talajvedelmi Szolgalat
(Plant and Soil Protection Board)
Hungary

MTA Talajtani es Agrokemiai Kutatointezet
(Soil and Agrochemical Research Institute)
Hungary

MTA Novenyvedelmi Kutatointezet
(Plant Protection Research Institute)
Hungary

Kornyezetvedelmi Intezet
(Institute of Environmental Protection)
Hungary

Department of Agriculture
Nepal

Ministry of Food & Agriculture
Kathmandu, Nepal

Soil Survey of Pakistan
Ministry of Food & Agriculture
Lahore, Pakistan

Environmental Sanitation Information
Center
Thailand

Institute of Agricultural Sciences
Korea

PCSIR Laboratory
Lahore, Pakistan

Ministry of Environment and Public Works
Greece

Department of the Protection of
Environment
Greece

Institute of Geological and
Mineral Research
Greece

Federal Environmental Protection Agency
Islamabad (Pakistan)

Bundesministerium fur
Wissenschaft und Forschung
Austria

Umweltbundesamt
Austria

APAP - Associacao Portuguesa dos
Arquitectos Paisagistas
1200 LISBOA

AGROBIO - Associacao Portuguesa de
Agricultura Biologica
1200 LISBOA

QUERCUS - Associacao Nacional de
Conservacao da Natureza
1200 LISBOA

Associacao Portuguesa de Arqueologia
Industrial
1100 LISBOA

APDA - Associacao Portuguesa para o
Direito do Ambiente
1200 LISBOA

Associacao Portuguesa dos
Engenheiros do Ambiente
1000 LISBOA

CAIPA - Comissao da Associacao Industrial
Portuguesa para O Ambiente
1399 LISBOA Codex

Associacao Portuguesa de Ecologistas
Amigos da Terra
1000 LISBOA

Associacao Portuguesa dos Recursos Hidricos
a/c L.N.E.C.
1799 LISBOA Codex

CEEETA - Centro de Estudos em Economia
da Energia, dos Transportes e do Ambiente
1200 LISBOA

Associacao dos Escoteiros de Portugal
1300 LISBOA

Corpor Nacional de Escutas
1200 LISBOA

CEOTA - Grupo de Estudos de Ordenamento
do Territorio e Ambiente
1200 LISBOA

LPN - Liga para a Proteccao da Natureza
1600 LISBOA

FAPAS - Fundo para a Proteccao dos
Animais Selvagens
4000 PORTO

The response from these overseas organisations was very positive, encouraging and extremely informative. We have received detailed reports, conference proceedings, policy documents etc. Apart from this we also wrote to individual scientists for their publication/s and response has been equally good.

National

Agricultural Institutes

The following agricultural institutes in India have been contacted through correspondence for information under agricultural chemistry and soils. (Departments of Soil Science,

Civil and Environmental Engineering and Environmental Sciences).

Assam Agricultural University
Jorhat ASSAM

Bidhan Chandra Krishi Viswavidyalaya
Distt. Nadia WEST BENGAL

Birsa Agricultural University
Ranchi BIHAR

Chandrashekhar Azad University of Agri. & Tech.
Kanpur U.P.

Govind Ballabh Pant Univ. of Agri. & Tech.
Dist. Nainital U.P.
Gujarat Agricultural University
Dantiwala Banaskantha GUJARAT

Haryana Agri. University
Hisar HARYANA

Himachal Pradesh Krishi Vishwavidyalaya
Palampur H.P.

Indian Agri. Research Institute
Pusa NEW DELHI - 110012

Jawaharlal Nehru Krishi Vishwavidyalaya
Jabalpur M.P.

Kerla Agricultural University
Trichur KERALA

Mahatma Phule Krishi Vidyapeeth
Ahmednagar MAHARASHTRA

Marathwada Krishi Vidyapeeth
Parbhani MAHARASHTRA

Narendra Deva Univ. of Agri. & Tech.
Faizabad U.P.

Orissa Univ. of Agri. & Tech.
Bhubaneswar Puri ORISSA

Punjab Agricultural University
Ludhiana PUNJAB

Punjabrao Krishi Vidyapeeth
Akola MAHARASHTRA

Rajendra Agricultural University
BIHAR

Sher-E-Kashmir Uni. of Agri. Sciences & Tech.
Dalgate Srinagar J & K

Tamil Nadu Agri. Uni.
Coimbatore TAMIL NADU

University of Agri. Sciences
GKVK Campus Bangalore KARNATAKA

We have written separately to departments of soil sciences, departments of environmental sciences and departments of civil and environmental engineering.

Indian Institutes of Technology

We have written to civil and environmental engineering and chemical engineering departments of all Indian Institutes of Technology (Kanpur, Bombay, Delhi, Madras and Kharagpur).

Engineering Colleges

We have written to the following engineering colleges (Department of Civil & Environment Engg. and Department of Chemical Engineering).

National Institute for Training in
Industrial Engineering
Bombay - 400 076

Jawaharlal Nehru Technological University
Hyderabad - 500 028

North-Eastern Regional Institute
of Science and Technology
Naharlagun Arunachal Pradesh-791 110

Cochin University of Science & Technology
Cochin - 682 002

University of Roorkee
Roorkee - 247 672

Regional Engineering College
Warangal - 506 004

Sardar Vallabhai Regional College
of Engineering and Technology
Surat - 395 007

Regional Engineering College
Kurukshetra - 132 119

Regional Engineering College
Hamirpur - 170 005

Regional Engineering College
Srinagar - 190 006

Karnataka Regional Engineering College
Srinivasnagar - 574 157

Regional Engineering College
Calicut - 673 601

Maulana Azad College of Technology
Bhopal - 462 007

Visweswaraya Regional Engineering College
Nagpur - 440 011

Regional Engineering College
Rourkela - 769 008

Regional Engineering College
Jalandhar - 144 008

Malaviya Regional Engineering College
Jaipur - 302 017

Regional Engineering College
Tiruchirapalli - 620 015

Motilal Nehru Regional Engineering College
Teliarganj Allahabad - 211 004

Regional Engineering College
Mahatma Gandhi Avenue Durgapur - 713 209

Regional Institute of Technology
Jamshedpur - 831 014

J N T U College of Engineering
Anantapur - 515 002

J N T U College of Engineering
Kakinada - 533 003

J N T U College of Engineering
Hyderabad - 500 488

Andhra University College of Engg.
Waltair - 530 003

Andhra University College of
Science and Technology
Waltair - 530 003

University College of Engineering
Osmania University Hyderabad - 500 007

University College of Technology
Osmania University Hyderabad - 500 007
SV University College of Engineering
Tirupati - 517 502

Kothagudam School of Mines
Kothagudam - 507 101

Assam Engineering College
Jalukbari Guwahati - 781 013

Jorha Engineering College
Jorhat - 785 007

Deptt. of Petroleum Technology
Dibrugarh University Dibrugarh

Bihar Institute of Technology
Sindri - 828 123

Bhagalpur College of Engineering
Bhagalpur - 813 210

Muzaffarpur institute of Technology
Muzaffarpur - 842 003

Bihar College of Enginering
Patna - 800 005

Birla Institute of Technology
Ranchi - 835 215

Department of Chemical
Engineering and Technology
Punjab University Chandigarh

Punjab Engineering College
Chandigarh - 160 014

Faculty of Engineering & Technology
Jamia Millia Islamiah
New Delhi - 110 025

Delhi College of Engineering
Delhi - 110 006

Delhi Institute of Technology
Delhi - 110 006

College of Engineering
Farmagudi Goa - 403 405

Faculty of Technology and Engineering
M S University of Baroda
Baroda - 390 001

LD College of Engineering
Navarangpura Ahmedabad - 380 015

Lukhdhirji Engineering College
Morvi - 363 012

Shantilal Shah Engineering College
University Campus Bhavnagar - 364 002

Government Engineering College
Modasa - 383 314

D D Institute of Technology
College Road Nadiad - 387 001

Centre for Environment Planning & Technology
Navarangpura Ahmedabad - 380 015

Engineering College
Murathal - 131 027

University Visvesvaraya College of Engineering
Bangalore - 560 001

Government BDT College of Engineering
Davangere - 577 004

Government SKSJ Technological Institute
Bangalore - 560 001

BMS College of Engineerng
Bangalore - 560 019

PDA College of Engineering
Gulbarga - 585 102

Malnad College of Engineering
Hassan - 573 201

BV Bhoomraddi College of Engg. & Technology
Hubli - 580 021

National Institute of Engineering
Mysore - 570 008

BVV Sangh s Basaveshwar Engineering College
Bagalkot - 587 101

P E S College of Engineering
Mandya - 571 401

Sri Jayachamarajendra College of Engineering
Mysore - 570 006

Government Engineering College
Trichur - 680 009

College of Engineering
Trivandrum - 695 016

Government College of Engineering
Cannanore - 670 001

Model Engineering College
Edappally Cochin

N S S College of Engineering
Palghat - 678 008

T K M College of Engineering
Quilon - 691 005

M A College of Engineering
Kothamangalam - 686 666

Government College of Engineering
Raipur - 492 002

Government Engineering College
Jabalpur - 482 001

Government Engineering College
Bilaspur - 495 009

Government Engineering College
Rewa - 486 002

Indira Gandhi Government Engineering College
Sagar - 470 005

Government Engineering College
Ujjain - 456 001

Government Engineering College
Jagdalpur - 494 001

Madhav Institute of Technology & Science
Gwalior - 474 005

Shri G S Institute of Technology & Science
Indore - 452 003

Samrat Ashok Technological Institute
Vidisha - 464 001

Sir J J College of Architecture
Dr Dadabhai Nauroji Road, Bombay

Department of Chemical Technology
University of Bombay Matunga
Bombay - 400 019

Laxminarayan Institute of Technology
University of Nagpur Nagpur - 440 010

College of Engineering
Osmanpura Aurangabad - 431 001

College of Engineering
Vidyanagar, Karad - 415 124

College of Engineering
Pune - 411 005

College of Engineering
Gadge Nagar, Amravati - 444 604

Victoria Jubilee Technical Institute
Matunga, Bombay - 400 019

Walchand College of Engineering
Vishram Bagh, Sangli - 416 415

Sardar Patel College of Engineering
Versova Road, Andheri
Bombay - 400 058

S G G S College of Engineering & Technology
Nanded - 431 602

University College of Engineering
Burla District Sambalpur - 768 018

Orissa University of Agricultural Technology
Bhubaneswar - 751 003

Indira Gandhi Institute of Technology
Sarang Talchar - 759 100

Pondicherry Enginnering College
Pondicherry - 605 104

Punjab Agricultural University
Ludhiana - 141 004

Longowal Institute of Engineering & Technology
Longowal Punjab

Guru Nanak Engineering College
Ludhiana - 141 006 Punjab

Thapar Institute of Engineering & Technology
Patiala - 147 001 Punjab

MBM Engineering College
University of Jodhpur
Jodhpur - 342 001 Rajasthan

College of Technology and Agricultural Engineering
Udaipur - 313 001 Rajasthan

Government College of Engineering
Kota - 324 001 Rajasthan

Birla Institute of Technology & Science
Pilani - 333 031 Rajasthan

College of Engineering
Anna University
Madras - 600 025 Tamil Nadu

A C College of Technology
Anna University
Madras - 600 025 Tamil Nadu

Madras Institute of Planning
Anna University Madras, Tamil Nadu

Faculty of Engineering & Technology
Annamalai University
Annamalainagar Tamil Nadu

Government College of Technology
Coimbatore - 641 013 Tamil Nadu

Government College of Engineering
Salem - 636 011 Tamil Nadu

Government Engineering College
Tirunelvely - 627 007 Tamil Nadu

A C College of Engineering & Technology
Karaikudi - 623 004 Tamil Nadu

Department of Technology
Annamalai University
Annamalainagar Tamil Nadu

P S G College of Technology
Coimbatore - 641 004 Tamil Nadu

Coimbatore Institute of Technology
Coimbatore - 641 014 Tamil Nadu

Thiagarajar College of Engineering
Madurai - 625 015 Tamil Nadu

Tripura Engineering College
Barjala Tripura - 799 055

Zakir Hussain College of Engineering & Technology
Aligarh Muslim University Aligarh - 202 002 (U.P)

Institute of Technology
Banaras Hindu University
Varanasi - 221 005

Dayalbagh Educational Institute
Dayalbagh Uttar Pradesh

National Sugar Institute
Kalyanpur Kanpur - 208 017

M M M Engineering College
Gorakhpur - 273 010 Uttar Pradesh

Kamala Nehru Institute of Science & Technology
Sultanpur Uttar Pradesh

H B Technological Institute
Nawabganj Kanpur
Uttar Pradesh

Institute of Engineering & Technology
Lucknow Uttar Pradesh

Allahabad Agricultural Institute
Allahabad - 211 007 Uttar Pradesh

Faculty of Engineering & Technology
Jadavpur University Calcutta - 700 032
West Bengal

Department of Applied Chemistry
University College of Technology
Calcutta - 700 009 West Bengal

Department of Applied Physics
University College of Technology
Calclutta - 700 009 West Bengal

Bengal Engineering College
Howrah - 711 103 West Bengal

Jalpaiguri Government Engg. College
West Bengal

V R Siddhartha Engineering College
Vijayawada Andhra Pradesh

Chaitanya Bharathi Institute of Technology
Hyderabad Andhra Pradesh

N B K R Institute of Technology
Vidyanagar - 524 413 Andhra Pradesh

Gandhi Institute of Technology and Management
Visakhapatnam - 530 040 Andhra Pradesh

M S Ramaiah Institute of Technology
Bangalore Karnataka

Manipal Institute of Technology
Manipal - 576 119 Karnataka

Dept. of Zoology
N.E.S. Science College
NANDED - 431 602

Dept. of Botany
Saraswati Bhuvan Science College
Aurangabad - 431 001

Other Institutes

We have contacted Indian Institutes of Management (Lucknow, Calcutta, Ahmedabad and Bangalore), and Indian Institute of Sciences, Bangalore, through correspondence.

Some research and development (R&D) units of public and private sector industries appear to be potential sources of information in connection with soil sciences and waste treatment. We have written to them also.

West Coast Paper Mills Ltd., Dandeli, Karnataka

Philips Carbon Black Ltd. (PCBL), Durgapur, West Bengal

Dunlop India Ltd., Calcutta

Richardson and Cruddas Ltd., Madras

ITC Ltd., Rajamundry, Andhra Pradesh

Office of Soil Conservation Research, Hazaribagh, Bihar

Soil Conservation Research Station, Jalalgarh, Bihar

Soil Conservation Research Demonstration and Training Centre, Jogbani, Bihar.

Projects & Development India Ltd., Sindri, Bihar

Rastriya Chemicals & Fertilizers Ltd., New Delhi

Biology & Agricultural Division of BARC, Bombay

Rallis Agrochemical Research Centre, Bangalore

The response within the country has not been much up to the mark. We hardly received any information from above listed institutes in India.

Literature Search:

Extensive literature search has been an important component of the project. Like any other research project, the entire process of information collection, collation, processing, storage and dissemination, has also occurred in the case of this project.

Manual search has covered libraries, documentation and information centres, R&D institutions in Delhi and a few other places. Both published and unpublished literatures have been acquired, processed, stored and organised.

The strategy followed for information collection and literature search -

We know that sources of information may be both documentary and non documentary.

Documentary Sources

primary secondary

tertiary

Non documetary

Conversations with colleagues and subject professionals.

Sharing experiences with groups working on the same discipline.

Participating in seminars, work-shops, focussing on similar/ related issues.

In the light of awareness about the existence of sources, we have defined a few clear-cut strategies in our search for documents on the concerned subject.

1. We have made personal visits to organisations, libraries and documentation centres. We have also contacted affiliated groups, grassroots workers and voluntary organisations.
2. We have contacted resource persons in getting latest and nascent information relating to the subject area under concern.
3. We have also made visits to important institutions outside Delhi after confirming about their information availability.
4. Besides the normal, regular materials like books, periodicals etc., we have scanned newsletters, bulletins, annual reports, brochures, pamphlets brought out by various organisations.
5. Our best efforts towards getting maximum information from house journals and reports of government, non-government and

international bodies, which give valuable information about innovations and experiments in specific fields of research.

6. Our inhouse library and documentation centre has some informative literature on the concerned research issue. So we have thoroughly reviewed our documents and research reports.

LITERATURE SEARCH AND COMPILATION

1. Literature search
2. Data collection/information acquisition
3. Information processing - technical and bibliographic
4. Compilation of database - using a software package
5. Information output - Bibliography

Literature search has taken into account both published and unpublished materials. Manual, on-line and are the three strategies followed for literature survey.

Data has been collected as a result of literature search, in the nature of bibliographical data, statistical data, guide to information sources, descriptive and qualitative data, and non-documentary information.

Information collected has been processed both bibliographically and technically. The complete bibliographical details of each reference have been worked out, after which the document has received scientific attention. Bibliographical processing has enabled in selecting only relevant materials and weeding out the irrelevant ones.

A database has been organised with the help of CDS/ISIS (2.3 version). Each reference has been treated as a single record and each record has all the necessary information, like author, title, source, year of publication, descriptor terms and abstracts. The arrangement has been designed so as to enable the user to search and retrieve information as quickly as possible. (For more details about this database, see Section 8. Database).

The bibliography is a direct output of the database. References have been compiled and alphabetically arranged. Each citation will have the following information - authorship, title, year of publication and source. But other details like keywords, abstract etc. may be looked up as and when required.

The following organisations (both government and non-government) have been visited and information acquired in the form of books, journal articles, conference proceedings, loose materials, reports, reprints and hard copies of database searches.

1. AFPRO (Action for Food Production)
2. Association of Scientific Workers of India
3. Centre for the Development of Instructional Technology(CENDIT)
4. Centre for Science & Environment
5. CORT (Consortium on Rural Technology)
6. Energy and Environment Group
7. Gandhi Peace Foundation - Environment Cell
8. International Commission on Irrigation & Drainage
9. Society for Development Alternatives
10. Society for Promotion of Waste Land Development (SPWD)
11. People's Environment Group

12. Soil Testing India (P) Ltd.

13. National Science Library - Indian National Scientific Documentation Centre.(INSDOC)

14. Shriram Institute for Industrial Research

15. Council for Scientific & Industrial Research, Library

16. SAIL Library (Steel Authority of India Ltd.)

17. Confederation of Engineering Industries, Library

18. Central Science Library , Jawaharlal Nehru University

19. Indian Council of Agricultural Research (IARI)

20. All India Soil and Land Use Survey

21. Department of Biotechnology - information section

22. Geological Survey of India (GSI)

23. National Institute for Science, Technology & Development Studies (NISTADS)

24. National Waste Lands Development Board (NWDB)

25. Soil and Minerals Research Station

We have also procured references which include names of books, journals/periodicals, research papers, dissertations, news bulletins and some news features. These references indicate that there is a substantial amount of literature existing with the organisations in the field of Soil Science and Wastes. We have followed up some of the citations in acquiring full length articles and papers. On-line computer search for literature has been executed at INSDOC, New Delhi. The internationally reputed 'DIALOG' Database has been accessed for references with abstracts. The references received have helped us in acquiring full length articles and papers from various professionals and scientists all over the world.

Visits to Specific Institutes:

Following National Institutes were visited for intensive information collection:

Industrial Toxicology Research Centre, Lucknow.

National Bureau of Soil Science and Land Use Planning, Nagpur

National Environmental Engineering Research Institute, Nagpur

All India Soil and Land Use Survey, Nagpur and Delhi.

Indian Agricultural Research Institute, Delhi.

4. SOILS OF INDIA

National Bureau of Soil Survey and Land Use Planning has recognised sixty four soils as bench mark soils of India. Each soil is a specific soil series from specific location. These locations have been selected from various parts of country. India is divided in seven parts for ease of understanding depending on geomorphological and ecological factors. Soil series from each part are listed below.

Soils of the Kashmir Valley

1. Gogji Pather series
2. Wahthora series

Soils of the Himalayan and Northern Mountains

3. Shinwali series
4. Phullen series
5. Dialong series
6. Selsekgiri series

Soils of the Indo-Gangetic Plains, the Brahmaputra Valley and the Tarai

7. Fatehpur series
8. Kanjli series
9. Nabha series
10. Zarifa Viran series
11. Sadhu series
12. Hirapur series
13. Sakit series
14. Itwa series
15. Bijaipur series
16. Basiaram series
17. Kanagarh series
18. Madhupur series
19. Hanrgram series
20. Jagdishpur series
21. Jaihing series
22. Gemotali series
23. Haldi series

Soils of the Desert Region

24. Chirai series
25. Pali series
26. Thar series

27. Masitawali series
28. Chomu series

Soils of the Black Soil Region

29. Sarol series
30. Kamliakheri series
31. Singpura series
32. Kheri series
33. Marha series
34. Jambha series
35. Linga series
36. Barsi series
37. Adesar series
38. Achmatti series
39. Hungund series
40. Kagalgomb series
41. Raichur series
42. Chougel series

Soils of the Red and Laterite Soil Region

43. Jamkhandi series
44. Tyamagondalu series
45. Vijayapura series
46. Channasandra series
47. Kadirabad series
48. Chinnaloni series
49. Kasireddipalli series
50. Patancheru series
51. Thekkadi series
52. Trivandrum series
53. Kunnamangalam series
54. Palathurai series
55. Coimbatore series
56. Pusaro series
57. Hathiapathar series
58. Mrigindihi series
59. Bhubaneswar series

Soils of the Coastal and Deltaic Region

60. Motto series
61. Kalathur series
62. Ambalapuzha series
63. Dandi series
64. Lakhpat series

Soil profile of each series was studied. Soil sample from different depths (i.e. horizons) for each profile were analysed for various physical and chemical properties of soils. These

properties include detailed particle size analysis, organic carbon, carbonate, pH, electrical conductivity, bulk density, water retention, micronutrients (Zn, Cu, Mn, Fe) extractable basis (Ca, Mg, Na, K) base saturation, cation exchange capacity etc. But it does not contain any information regarding major nutrients (NPK&S) and trace elements, toxic elements etc. which limits its usefulness. Various characteristics of sixty four soil series are presented in forthcoming table which also includes altitude, average temperature and rainfall and land use pattern of the respective area. (See table 4.1).

Apart from these details, India has also been divided in twenty one agro ecological regions (see map). Twenty one soil series were selected from each series and were characterized as shown in following table. This table also does not provide enough information to understand the chemical behaviour of soils. (See fig. 4.1 and table 4.2).

TABLE 4.1 : DETAILED CHARACTERIZATION OF 64 SOILS SERIES OF INDIA (ALSO KNOWN AS BENCH MARK SOILS OF INDIA)

SOILS OF	SOIL SERIES	ALTITUTE	MEAN ANNUAL TEMPER-ATURE DEGREE C	MEAN ANNUAL RAINFALL mm.	LANDUSE	HORIZONS	DEPTH cm.	SIZE CLASS AND PARTICLE DIAMETER (mm) TOTAL SAND 2-0.05	SILT .05-.002	CLAY 0.002	S VERY COARSE 2-1 (% of 2mm)	A COARSE 1-0.5	N MEDIUM .5-.25	D FINE .25-.1	VERY FINE .1-.05	SILT .05-.02	.02-.002	COARSE FRAGMENTS 2mm% of whole soil	ORGANIC CARBON %	CARBONA-TE AS CaCO3 2mm %	EXT. IRON AS Fe %	pH (1:2.5) H2O	BULK DENSITY
J & K	Gogji pather	1600	13.3	580	Wheat Maize Saffron	Ap	0-15	6.3	79	14.7	-	0.1	0.4	0.6	5.2	31.6	47.4	-	0 37			8	1 55
						A12	15-23	5.1	90 3	14.6	-	0.1	0.1	0.3	4.6	29 5	50.8	-	0.33			7.9	1 62
						B2t	27-71	5.3	66 7	28	-	0.1	0.1	0.1	5	21 5	45 2	-	0 25			7 8	1.45
						C1	71-93	7.8	66 2	26	-	0.8	0.8	1.7	4.5	19 7	46.5	3	0.22			8.4	1.41
						C2	93-124	7.5	66.1	26.4	0.1	1.6	0.8	1.9	3.1	22.5	43 6	3	0.19			8 2	1 41
						C2ca	124-140	12.1	65 2	22.7	1.6	4	1 2	1.3	4	20.2	45	28	0.19			8.2	1.45
J & K	Wahthora	1600	12.6	580	rice mustard willow poplar	Ap	0-4	21	66 2	12 8	-	0.1	2 5	5.5	12.9	19	47.2	-	0.99	1	0.5	7 1	1 45
						A12	4-27	21.1	68 4	10 5	-	-	0.4	1.6	19.1	33.3	55.1	-	0 53	1	1.75	7 1	1.49
						A3	27-40	16 5	71	12 5	-	-	0 4	1.5	14 6	26.7	44 3	-	0 43	1	1.72	6 7	1.49
						11B21g	40-51	8 3	70 9	20 8	-	0.1	0.1	0.9	7.2	16.7	54 2	-	0.36	1	0.79	7	1 49
						11B22g	51-72	9 4	69 2	22 4	-	0.1	0.2	0.5	7 6	11 2	57	-	0 33	1	0.86	6.8	1.52
						11B3g	72-111	7.8	66 9	25 3	-	0.1	0.3	0.6	7.8	12	54.9	-	0 36	2	1.06	6.9	1 55
Uttar Pradesh	Ch.-wali	1500	14 5	1800	maize millet sal eugenia pinus lantana grasses	Ap	0-12	41.7	45.2	13 1	4.4	12.4	6.8	9.4	8.7	6.3	38.9	50	0.96		0.66	6.1	1.7
						AC	12-34	37.5	47	15.5	1.9	9.7	7 3	9.6	9	6 7	40 3	70	0.48		0.66	6 1	1 26
Mizoram	Phullen		20.1	2260	Dense Bamboo forest	A1	0-15	11.8	55.1	33.1								36	0 73			5 2	
						C	15-39	9.7	61	29.3								71	2.7			5.7	
Manipur	Dialong		20.4	1350	moist jhum	A1	0-15	44.6	28	27.4								10	1.74			4.5	
						B2t	15-29	34 6	29	36 4								13	0 77			4.4	
						B3	29-61	44.6	26	29.4								46	0.5			4.4	
Meghalaya	Selsekgiri		24	3350	moist jhum	A1	0-15	8	32 9	31 6								2	2 37			4	
						B1t	15-38	6.3	28 9	37.6								2	1.68			4.1	
						B2t	38-120	4 4	29 9	47.6								2	0.69			4	
Punjab	Fatehpur	230-300	24.3	570	Groundnut pearl maize wheat Zizyphus Saccharum	Ap	0-15	83.1	11.4	5.5	-	3.1	16.5	51.7	11.8	9.2	2.2	-	0.12	-		7.8	
						A12	15-25	77.5	14.1	8.4	-	3	14.1	49.8	10.6	10.1	4	-	0.11	-		7.8	
						B21	25-47	78.6	12.5	8.9	-	3	15.5	47	13.1	8.3	4.2	-	0.05	-		7.8	
						B22	47-63	79.7	12.1	9.2	-	3	15.8	46.3	13.6	8.1	4	-	0.07	-		7.7	
						B23	63-75	78.7	12	9.3	-	3	16.6	46	13.1	9	3	-	0.03	-		7.8	
						B24	75-100	76.7	15.8	7.5	-	3.1	17.7	42.9	13	10.3	5.5	-	0.03	-		7.7	
						B25	100-117	74.4	17.8	7.8	-	3.2	14	44.8	12.4	14.8	3	-	0.03	Tr		7.6	
						B26	117-123	76.4	16.2	7.4	-	3.2	15.9	43.3	14	14.1	2.1	-	0.03	1		7.6	
						C1	125-143	79.4	13.8	6.8	-	3.2	14.2	45.1	16.9	8.6	5.2	-	0.03	Tr		7.6	
						C2	143-165	82.6	10.9	6.5	-	3.1	19.9	42.3	17 3	7.5	3 4	-	0.03	Tr		7.7	

MICRO NUTRIENTS D T P A EXTRCTABLE Zn	Cu (ppm)	Mn	Fe	EXTRACTABLE BASES Ca	Mg me/100g	Na	K	Sum	CEC NH4OAc	BASE SATURA-TION NH4OAc	RATIO CEC/ CLAY	EXT. IRON	E.C. (1:2.5) H2O mmhos/ cm	Ca+Mg me/100g
0.32	1.42	15	7	7.5	2.5	0.8	0.4	11.2	11.1	100	0.77		0.7	
0.37	1.49	21	7	8.7	2	0.9	0.5	12.1	12.1	100	0.33		0.6	
0.21	1.6	19	9	8.2	4	1.2	0.6	14	14.3	98	0.51		0.6	
0.17	0.64	7	6	8	3	1.5	0.3	12.8	13.4	95	0.52		0.7	
				9	5	1.4	0.3	14.7	15	99	0.57		0.5	
				6	4	1.6	0.4	12	13	93	0.57			
1.54	4.6	78	51	1.5	1.7	0.3	0.2	3.7	4.3	89	0.34	0.04		
1.38	3.7	51	42	1	2.7	0.3	0.2	4.2	4.3	99	0.41	0.17		
0.2	2.92	18	23	1	3	0.2	0.3	4.5	4.6	97	0.37	0.14		
0.16	1.9	15	22	0.7	4.1	0.2	0.2	5.2	5.4	97	0.26	0.04		
0.17	1.78	26	19	1.1	4.2	0.3	0.1	5.7	6	97	0.26	0.04		
1.15	1.73	24	18	1.1	3.7	0.8	0.1	5.7	6.1	94	0.24	0.04		
0.7	0.96	38	22	1.2	0.8	0.6	0.2	2.8	3.4	88	0.27	0.05		
0.29	1.67	14	22	1.6	1	0.6	0.3	3.5	3.7	94	0.24	0.04		
									16.4	60	0.49			
									12	60	0.41			
									14.4	55	0.52			
									17.6	52	0.48			
									14.6	55	0.5			
									25.1		0.8			
									26.8		0.71			
									28.9		0.61			
0.82	0.32	9	15			0.1	0.1	3.6	3.6	100	0.65		0.8	3.4
0.24	0.36	7	18			0.1	0.1	4.1	4.2	98	0.5		0.7	3.9
0.31	0.3	11	16			0.1	0.1	4	4	100	0.45		0.6	3.8
0.22	0.31	11	14			0.1	0.1	5	5.1	98	0.55		0.9	4.8
0.15	0.31	12	13			0.1	0.1	6.1	6	102	0.65		1	5.9
0.18	0.32	12	14			0.1	0.1	3.9	3.9	100	0.52		0.8	3.7
						0.1	0.1	3.7	3.7	100	0.47		0.8	3.5
						0.1	0.1	3.8	3.8	100	0.51		0.7	3.6
						0.1	0.1	3	3.1	97	0.46		0.8	2.3
						0.1	0.1	3.1	2.9	111	0.43		0.9	2.9

Punjab	Kanjli		24.3	670	wheat	Ap	0-22	23.9	56	20.1	-	0.4	2.7	8.5	12.3	15.2	40.8		0.68	1.6	0.26	7.8	
					rice	B1	22-47	20.9	57.9	21.2	-	0.1	0.7	8.4	11.7	16.4	41.5		0.27	2.2	0.6	7.9	
					sugarcane	B2	47-64	24	51.2	24.8	0.4	0.4	5.7	8.3	9.2	10.2	41		0.23	0.8	0.81	7.9	
					lucerne	IIB31	64-77	40.4	38.6	21	-	0.7	12	17.4	10.3	10.4	28.2		0.24	0.8	0.71	7.9	
					Acacua	IIB32	77-103	53.8	32.6	13.6	-	0.7	16.3	24.7	12.1	10.3	22.3		0.12	0.5	0.71	7.8	
					Dalbergia	IIB33	103-124	53.6	31.1	15.3	-	0.8	16.7	22.9	13.2	10.2	20.9		0.11	1	0.69	[illegible]	
					grasses	IIB34	124-140	51.9	37.7	10.4	-	0.6	13.1	22.8	15.2	12.7	25		0.08	0.8	0.69	7.9	
						IIIC1	140-160	70.7	20.9	8.5	-	0.6	23.4	39.9	7.9	5.8	15		0.09	0.5	0.55	7.8	
						IIIC2	160-180	73.7	21	5.3	-	0.9	27.5	38.1	7.2	5.9	15.1		0.08	0.4	0.4	7.8	
Punjab	Nabha	200-300	25	450-850	maize	Ap	0-19	33.6	50.5	15.9	0.1	0.4	3.7	12.6	16.8	23.7	26.8		0.4	Tr	0.52	8.1	1.54
					sorghum	A3	19-31	35.2	50.7	14.1	0.1	0.4	5	11.6	18.1	24.5	26.2		0.29	Tr	0.66	8.1	1.51
					pearl	B21	31-45	24.1	45.4	30.5	-	0.2	1.9	8.1	13.9	17.8	27.6		0.3	Tr	0.92	7.9	1.42
					rice	B22	45-73	22.8	47.3	29.9	0.1	0.4	1.3	6.7	14.3	17.1	30.4		0.25	Tr	0.92	7.7	1.42
					pea	B23	73-105	26.6	40.5	32.9	0.2	1	1.4	6.7	17.3	17.2	23.2		0.25	Tr	1.07	7.6	1.39
					mustard	B3	105-136	31.1	40.8	28.1	0.2	0.6	2	8.4	19.9	17	23.8		0.16	Tr	0.92	7.7	1.37
					sugarcane	C	136-156	41.8	38.1	20.1	-	0.4	1.3	12.7	27.4	17.7	20.4		0.1	Tr	0.81	7.7	1.44
Haryana	Tarifa	200-250	25	500-700	Barren	A11	0-5	43.4	34.6	22		0.2	1.2	3.2	38.8		19.1		0.3	0.5		10.3	
					Grasses	A12	5-24	33.4	37.6	29		0.3	0.3	1.9	30.9		24.6		0.3	0.9		10.3	1.43
						B21t	24-56	30.6	36.2	33.2		0.4	0.3	1.8	28.1		26.2		0.2	1.4		9.8	
						B22t	56-85	26	42.6	31.4		0.2	0.4	1.6	23.8		24.2	4	0.2	3.3		9.8	1.53
						B3ca	85-118	33.2	40	26.8		0.6	0.8	1.6	30.2		23	10	0.1	1.4		9.6	1.47
						Ccca	118-140	45	32	23			0.1	0.4	44.5		19.6		0.1	20.5		9.2	
Punjab	Sadhu	200-300	25.5	820	Rice	Ap	0-9	3.7	35.5	60.7		0.5	0.5	1.9	0.8	11.4	24.2		0.75	0.4	0.82	8.1	1.41
					Wheat	A3	9-23	7.2	30.8	62	0.4	0.6	0.5	1.7	4	7.7	23.1		0.42	0.2	0.87	8	1.45
					Gram	B21	23-46	5.2	27.3	67.5	0.3	0.6	0.3	0.7	3.3	7.3	20		0.3	0.4	0.87	8.1	1.47
					Acica	B22	46-62	4.7	28.2	67.1	0.2	0.4	0.2	0.7	3.2	7.9	20.4		0.29	0.4	0.92	9.1	1.46
						B23	62-88	5.2	23.7	71.1	0.1	0.4	0.2	0.7	3.8	7.5	16.2		0.3	0.4	0.95	9.2	1.44
						B24	88-112	3.8	31.3	64.9		0.3	0.2	0.1	3.2	7	24.3		0.27	0.3	0.94	8.2	1.42
						B3	112-134	6.7	25	68.3	0.2	0.8	0.5	0.9	4.3	6.3	19.7		0.26	0.1	0.77	8.4	1.39
U.P	Hirapur	150-200	25.7	775	Barren	A1	0-10	65.4	19.8	14.8		0.2	0.3	15.2	49.7		11.4		0.3	2		10.4	
					Grass	A3	10-42	56.9	20.1	23		0.1	0.4	11.1	45.3		18.5		0.2	2		10.3	
						B1	42-71	54	20.8	25.2		0.4	0.5	10.8	42.3		18.5		0.7	2		10.2	
						B3	71-106	50.2	22.6	27.2		0.3	0.4	7.4	42.1		19.6		0.1	3		9.8	
						C1ca	106-122	53	20.6	26.4		1.7	0.1	4.2	47		19.6		0.1	8		9.7	
						C2ca	122-150	57	22.6	20.4		0.3	0.5	4.8	51.4		16.1		0.1	7		9.3	
U.P	Sakit	150-200	25	675	Barren	A11	0-11	64.6	17.2	18.2				5.9	55.7		14		0.4	0.8		10.5	
					Grass	A12	11-38	52.4	22.4	25.2		0.5	0.6	8.4	42.9		19.8		0.3	1		10.4	
						B21t	38-49	41	25.4	33.6		0.3	0.4	5.4	34.9		23.8		0.3	0.9		10.2	
						B22t	48-69	41	27.4	31.6		0.4	0.4	3.7	36.5		23		0.2	0.9		10.1	
						B23t	69-94	42.8	29.4	27.8		1	1	7.8	33		21.2		0.2	3		10	
						C1ca	94-121	47.6	25	27.4		2.6	2	3.6	39.4		21.9		0.1	20.1		9.6	
						IICca	121-142	50.2	25.2	24.6		0.2		1.6	38.4		22		0.1	21.6		9	
U.P	Itwa	150-200	26	1100	Rice	Ap	0-8	12.4	65.1	22.5		0.3	0.2	0.4	11.5	32.1	33.6		0.42	Tr	0.55	6.6	1.49
					Barley	A3	8-30	9.7	59.9	30.4	0.1	0.2	0.2	0.2	9	28.1	31.8		0.21	Tr	0.64	6.6	1.4
					Gram	B2t	30-81	10.7	50.4	38.9	0.2	0.2	0.2	0.4	9.7	20.6	29.8		0.21	Tr	0.65	6.7	1.57
					Butes	B3t	81-94	11.9	49.1	39	0.4	1.6	0.6	0.8	8.5	16.7	32.4	16	0.24	3.8	0.74	7.7	1.65
					Acacia	IICca	94-132	32	43.2	24.8	3.7	11	4.8	4.7	7.8	11.8	31.4	40	0.19	36.6	0.54	7.9	1.65
U.P	Bijaipur	150	25.9	885	Wheat	Ap	0-17	31.2	58.7	10.1	0.1	0.2	0.2	0.4	30.3	27.3	31.4		0.18		0.66	6.8	
					Rice	A12	17-32	17.8	60.1	22.1		0.2	0.2	0.4	17	28.2	31.9		0.11		1.15	6.9	
					Acacia	B21	32-61	15.1	59.9	25		0.1	0.7	0.4	13.9	28.3	31.6		0.15		1.25	6.8	
					Zizyphus	B22	61-84	15	55.2	29.8		0.2	0.2	0.5	14.1	24.4	30.8		0.15		1.18	6.7	
						B3	84-119	13.8	54	32.2		0.2	0.2	0.5	12.9	22.8	31.2		0.15		1.36	6.7	

0.48	2.36	18	12	4.6	2.9	0.9	1.3	9.7	10	96	0.5	0.01	0.75	
0.22	1.65	16	12	4.8	3.1	0.7	1.5	10.1	10.5	96	0.5	0.03	0.62	
0.86	1.71	17	12	4.7	3	1	0.8	9.5	10.1	93	0.41	0.03	0.85	
0.1	0.81	13	9	4.9	2.5	0.7	0.8	8.9	9.2	98	0.44	0.03	0.61	
0.15	1.47	17	10	4.5	2.2	0.4	0.9	8	8.1	99	0.59	0.05	0.66	
				4.5	1.7	0.5	1	7.7	8.3	87	0.54	0.04	0.44	
				4.1	1.7	0.8	0.6	7.2	7.8	93	0.75	0.07	0.65	
				3.2	2.5	0.7	0.8	7.2	7.7	94	0.91	0.06	0.53	
				3.4	2	0.6	0.4	6.4	7	91	1.32	0.07	0.07	
0.37	1.22	14	7	5.5	2	1.2	0.4	9.1	9.8	94	0.61	0.03	0.53	
0.2	1.01	11	7	5.2	2.2	1.1	0.3	8.8	8.9	98	0.63	0.04	0.44	
0.14	1.11	20	8	9	3.7	1.2	0.3	14.2	14.3	99	0.46	0.03	0.37	
0.15	1.05	17	7	8	3.7	1.5	0.4	13.6	14.3	95	0.47	0.03	0.39	
0.21	0.88	11	5	6.7	3.1	1.4	0.4	11.6	11.7	99	0.35	0.03	0.43	
				6.7	4.4	1.3	0.4	12.8	13	98	0.46	0.03	0.47	
				6.9	3.4									
0.36	2.01	12	9			9.9	0.1		10.2	33	0.46			0.2
0.36	2.32	9	16			12.1	0.4		12.8	39	0.44			0.3
0.34	1.39	11	6			13.4	0.6		14.8	32	0.45			0.8
0.21	0.8	9	5			12.4	0.4		14.6	40	0.46			1.8
0.21	0.5	6	4			7.6	0.5		11.2	40	0.41			3.1
						3.8	0.4		9.8	44	0.41			5.6
0.28	2.3	8	32			2.6	0.9		30.4		0.5	0.02	0.73	
0.12	1.46	7	12			2.4	0.8		30.4		0.49	0.02	0.56	
0.14	1.38	7	11			2.2	0.8		32.6		0.48	0.02	0.64	
0.14	1.41	8	11			2	0.8		31.5		0.47	0.02	0.77	
0.13	1.28	7	10			2	0.8		31.5		0.44	0.02	0.7	
0.17	1.25	7	10			1.6	1		32.6		0.5	0.02	0.69	
						1.1	0.5		28.3		0.41	0.02	0.88	
0.27	0.94	4	10			6.5	0.2		6.8	39	0.47		44.4	
0.15	1.42	9	20			9.1	0.3		9.8	38	0.43		13.9	
0.07	0.58	10	7			9	0.5		10.4	35	0.41		3.3	
0.07	0.27	6	4			10	0.6		12.2	35	0.45		2.1	
						7.2	0.5		10.5	40	0.4		1.6	
						3.1	0.4		7.8	37	0.38		1	
0.59	0.91	7	30			7.9	0.3		8.3	47	0.45			0.1
0.31	2.56	9	24			11.8	0.4		12.6	46	0.5			0.4
0.3	1.47	5	15			12.8	0.4		14.1	62	0.42			0.9
0.12	0.59	4	11			13.2	0.6		15.2	56	0.48			1.4
0.15	0.3	3	7			10.2	0.4		12.8	53	0.46			2.2
						4.5	0.6		9	47	0.32			3.9
						2.5	0.5		8.8	57	0.35			5.8
0.5	2.0	19	51	4.7	3.5	1.2	0.7	10.1	11.6	88	0.52	0.02	0.33	
0.13	1.45	15	10	7	4	1.1	0.6	12.7	13.7	93	0.45	0.02	0.37	
0.12	1.06	9	8	9	3	2	0.7	14.7	5.1	97	0.39	0.02	0.3	
0.12	0.7	4	5	9	4	1.7	0.6	15.3	15.7	98	0.4	0.02	0.64	
				4.5	3	1.2	0.4	9.1	9.2	100	0.37	0.02	0.54	
0.6	1.56	55	33	3	2	0.3	0.2	5.5	5.4	100	0.53	0.06		
0.46	1.02	36	18	4.5	3	0.4	0.2	8.1	8.6	94	0.39	0.05		
0.31	1.04	39	18	4.5	3.5	0.5	0.8	9.3	10.3	90	0.41	0.05		
0.22	0.93	39	17	7.5	3	0.6	0.9	12	12.7	95	0.43	0.04		
0.18	0.78	35	14	7	4	0.6	1	12.6	13.6	93	0.42	0.04		

						IIC	119-139	12.3	54.4	33.3		0.1	0.1	0.5	11.6	18.9	35.5		0.12		1.34	6.9	
							139-172	19.2	57.4	23.4		0.1	0.1	0.4	18.6	29.7	27.7		0.06		1.34	6.9	
U.P	Basiran	75-100	26	1140-1700	Wheat	Ap	0-13	24.2	65.5	10.6		0.4	0.7	3.4	20	37.3	28.2		0.48	Tr	0.29	7.2	1.17
					Rice	A3	13-28	24.5	60.5	15	0.2	0.3	0.2	3.5	20.3	33	27.5		0.25	Tr	0.44	7.4	1.23
					Sugarcane	B21	28-44	20.5	58	21.5	0.1	0.3	0.3	2.6	17.2	26.5	30.2		0.15	Tr	0.79	7.4	1.2
					Pigeonpea	B22	44-82	16.2	59.5	25.3	0.1	0.5	0.3	1.6	13.7	26.9	31.6		0.15		1.09	7.3	1.25
					Gram	B23	82-110	21.7	57	21.3	0.6	0.5	2	1.5	17.1	27.2	29.8		0.12		1.02	7.3	1.3
					Pulses	B31	110-136	11.6	65.8	22.6	0.1	0.2	0.2	1.3	9.8	18.9	47		0.07		1.24	7.2	1.32
					Acacia	B32	136-170	8.3	62.7	29	0.1	0.1	0.1	1.4	6.6	11.3	49.4		0.07	Tr	1.44	7.1	1.74
					Mango																		
W. Bengal	Panagarh	5-10	27.5	1810	Rice	Ap	0-12	1.2	69.5	29.3				0.4	0.8	21.2	48.3		1.36		0.56	7.7	
					Wheat	A12	12-24	1.4	67	31.6				0.5	0.9	19.9	47.1		0.75		0.53	7.5	1.74
					Pulses	C1g	24-41	1.7	72.1	26.2				0.2	1.5	20.8	51.3		0.48		0.6	7.5	
					Ficus	C2g	41-55	0.5	73.5	26				0.1	0.4	22.1	51.4		0.42		0.46	7.7	1.47
					Cyndon	IIC3g	55-71	0.4	84.4	15.2				0.1	0.3	34	50.4		0.26		0.56	7.9	
					Panicum	IIC4g	71-86	0.3	76.4	23.3				Tr	0.3	26.6	49.8		0.4		0.7	7.9	1.68
					Cyprus	IIC5g	86-99	2.3	78.4	19.3				0.4	1.9	24.9	53.5		0.35		0.64	8	
					Teak	IIC6g	99-140	0.5	57.3	42.2				0.2	0.3	4.7	52.6		0.42		0.36	7.7	
					Palmyra																		
W. Bengal	Madhupur	10-50	20.3	1730	Rice	Ap	0-13	6.3	76.4	17.3				0.7	5.6	30.4	26		0.65		0.46	8	1.75
					Jute	B1	13-35	2.2	77	20.8				0.4	1.8	27.5	49.5		0.42		0.37	9.1	1.52
					Pulses	B21	35-53	2.4	66.9	30.7				0.2	2.2	21.9	45		0.45		0.12	7.9	1.71
					Oilseed	B22	53-67	9	65.2	25.8				0.9	8.1	34.3	30.9		0.35		0.14	7.9	1.84
					Acacia	C1	67-87	24.8	59.6	15.6				2.1	22.7	41.4	18.2		0.17		0.38	8.2	1.77
					Palmyra	C2	87-118	30	57.2	12.8				1.3	28.7	42.9	14.3		0.13		0.2	8.3	
						IIC3	118-132	5.4	67.3	27.3				2.2	3.2	17.8	49.5		0.17		0.25	8.2	
W. Bengal	Hansgram	[illegible]	26.6	1400	Rice	Ap	0-11	17.5	36.1	46.4	0.8	1.4	4.8	6.4	4.1	6.3	29.8		1.26		0.81	5.5	1.56
					Wheat	A3	11-25	17.4	34.2	48.4	0.3	0.8	4	7.6	4.7	6.6	27.6		0.27		1.16	6.4	
					Ficus	B1	25-56	17.3	34.7	48	0.1	0.9	3.5	8.6	4.2	7.6	27.1		0.22		0.67	6.3	1.79
					Solanum	B21	56-84	17.3	32.3	50.4	0.1	0.9	4.4	7.8	4.1	7.1	25.2		0.19		1.02	6.1	
					Palmyra	B22	84-105	17	26.7	56.3	0.1	0.6	4.7	7.9	3.7	7.5	19.2		0.19		0.46	6.3	1.68
					Silk	B23	106-131	17.6	26.4	56	0.1	0.6	5.4	7.5	4	8.5	17.9		0.17		0.37	6.5	
W. Bengal	Jagadishpur	20-50	26.5	1380	Rice	Ap	0-13	9.5	70.8	19.7	0.4	0.9	2.5	3.6	2.1	48.7	22.1		0.74		0.7	5	1.55
					Wheat	A3	13-29	12.1	66.5	21.4	0.2	0.8	1.8	3.9	5.4	42.1	24.4		0.48		0.8	6.3	
					Pulses	B1	29-43	10.2	59.3	30.5	0.4	0.9	1.7	3.8	3.4	38.2	21.1		0.31		1.2	6.2	1.65
					Oilseed	B21t	43-62	8.1	59.4	32.5	0.2	0.4	1.1	3.4	3	41.7	17.7		0.27		1.2	6	
					Neem	B22t	62-93	6.7	52.9	40.4	0.1	0.3	1.1	2.4	2.8	42.1	10.8		0.27		1.2	5.8	1.54
					Blackberry	B23t	93-112	6.8	50.9	42.3	0.1	0.4	1.2	2.7	2.4	39.4	11.5		0.19		1.1	5.8	
					Date	B24t	112-130	5.3	51.9	42.8	Tr	0.4	1.1	1.6	2.2	39.5	12.4		0-19		1.1	6	
					Cynodon																		
					Saccharum																		
Assam	Jaihing		24	1820	Tea	A1	0-16		21.3	24.3	8.4	46						2	1.29			4.2	
						B1	16-61		22.8	26	11.1	40.1						2	0.81			4.5	
						B2	61-92		24.6	26	8.7	40.7						2	0.6			4.5	
						C	92-150		18.1	20.9	7.4	53.6						2	0.18			4.6	
A.P	Semotali		24	2150	Rice Vegetable	A1	0-7	66.3	14.8	18.9									2.68			4.8	
						B1	7-26	66.7	13.8	19.5									1.62			5	
						B2t	26-54	61	13.5	25.5									0.59			5	
						B3t	54-89	68	12.5	19.5								5	0.37			5.2	
						C1	89-110	86	3.5	10.5								7	0.28			5.4	
U.P	Haldi	200-250	23.2	1380	Maize	Ap	0-20	36.8	45.4	17.8	0.2	3.8	6.4	14.6	11.8	11	34.4		0.71		0.91	7.1	1.47
					Soybean	A12	20-27	35.3	47.2	17.5	0.3	3.3	4.8	13.7	13.2	11.3	35.9		0.72		0.8	7.1	1.56
					Wheat	A3	27-43	36.6	45.6	17.8	0.1	2.3	4.3	15.2	14.7	10.7	34.9		48		0.8	7	1.46

IV

				7	4.5	0.7	0.8	13	13.5	97	0.4	0.04	
				6.5	4	0.8	0.7	12	12.6	95	0.54	0.06	
0.73	2.9	41	39	2.3	2.3	0.6	0.3	5.5	6.3	94	0.61	0.03	0.34
0.3	2.06	23	12	3	2.5	0.6	0.9	7	7.5	93	0.5	0.03	0.45
0.6	1.02	40	11	3.3	2.5	0.8	0.9	7.5	8.5	87	0.4	0.04	0.4
0.25	0.95	20	8	3	2.5	1.3	1.8	8.6	10.6	85	0.42	0.04	0.42
0.25	0.42	19	6	4	2.5	1.5	0.9	8.9	9.8	91	0.46	0.05	0.32
				4.3	3	1.5	0.8	9.6	10.1	94	0.45	0.05	0.46
				5	2.3	1	0.9	9.2	10.2	94	0.35	0.05	0.31
0.29	5.1	8	45	8.4	6.2	1	0.8	16.4	18.4	89	0.63	0.02	
0.21	3.3	9	20	9.2	7.4	1.6	1.1	19.3	21.6	89	0.68	0.02	
0.17	1.1	4	9	7.8	6	0.8	0.8	15.4	16.2	95	0.62	0.02	
0.14	0.7	4	6	6.8	6.2	0.9	0.7	14.6	15.1	97	0.58	0.02	
0.13	0.8	2	5	5.7	3.5	0.4	0.4	10	10.8	93	0.71	0.04	
0.2	0.3	3	5	6.4	3.8	0.9	0.6	11.7	13	90	0.56	0.03	
0.09	0.3	3	4	4.4	4.2	0.9	0.8	10.3	11.9	87	0.62	0.03	
				9	7.4	0.7	0.2	17.3	20.8	83	0.49	0.09	
0.32	1.89	7	8	7.2	2.9	0.2	0.4	10.7	13	82	0.75	0.03	
0.14	0.91	8	6	12.9	3.4	0.8	0.5	17.6	18.4	96	0.88	0.02	
0.14	1.15	9	7	20.9	3.9	0.9	0.9	26.6	29	92	0.94	0.01	
0.16	1.04	5	6	8.4	3.5	1	1.3	14.2	15.1	94	0.59	0.01	
0.12	0.39	4	3	4.2	3	1.1	0.3	8.6	9.7	89	0.62	0.02	
0.12	0.19	3	4	4.7	2.8	0.7	0.6	8.8	10	88	0.78	0.02	
				5.8	4.4	0.8	0.4	11.4	13	88	0.48	0.01	
0.97	4.46	102	51	11.2	2.4	0.5	0.3	14.4	18.4	78	0.4	0.02	
0.24	1.22	19	11	13.6	4.4	0.7	0.4	19.1	21.6	88	0.45	0.02	
0.25	0.96	4	12	14.4	4	0.4	0.4	19.2	22	87	0.46	0.01	
0.34	1.02	8	15	15.2	4.9	0.4	0.5	20.9	23	91	0.45	0.02	
0.32	0.99	7	14	16.8	5.2	0.5	0.5	23	24.2	95	0.43	0.01	
				17.6	8.4	0.5	0.6	27.1	28	91	0.5	0.01	
0.7	4.86	76	51	9	4.4	0.2	0.3	12.9	17.6	73	0.89	0.04	
0.13	1.31	13	16										
0.14	0.84	9	14	12.4	5.2	0.2	0.4	18.2	19.8	92	0.65	0.04	
0.2	0.63	14	14	14.4	5.6	0.2	0.5	20.7	22.6	91	0.69	0.04	
0.25	0.56	12	114	18	4.4	0.2	0.6	23.2	26	89	0.64	0.03	
				18.9	4.4	0.5	0.7	24.4	27.6	88	0.65	0.03	
				19.2	6	0.4	0.7	26.3	28	94	0.65	0.03	
										50	0.55		
										55	0.55		
										53	0.61		
										57	0.63		
										57	0.53		
										51	0.59		
										50	0.63		
										50	0.69		
										55	0.61		
1.86	1.99	47	59	3.5	1.5	0.5	0.8	6.3	7.4	85	0.41	0.05	0.39
0.42	2.9	15	38	4.2	2	0.4	0.4	7	8	89	0.45	0.04	0.43
0.36	2.61	16	32	4	2.5	0.5	0.4	7.4	8	93	0.44	0.04	0.47

					Tiger Grass	B21	43-67	37.2	44.1	18.7	0.2	2.3	4.9	14.7	15.1	11.9	32.2		0.42		0.3	7	1.46
					Reedgras	B22	67-80	34.9	49.1	16	1.3	3.6	3.3	11	15.7	15.7	33.4		0.33		0.3	7.1	1.51
					Pragmetes	B3	80-106	35.2	47.3	17.5	0.3	1.3	1.7	11.5	20.4	19	28.3		0.2		0.31	7.3	1.53
						C1	106-119	59.8	28.5	11.7	0.3	1.3	3.3	25.3	29.6	10.8	17.7		0.21	Tr	0.41	7.5	1.56
						IIC2	119-128	56.7	31.8	11.5	0.3	1.6	2.6	17.6	28.6	19.5	15.3		0.15	Tr		7.7	
Rajasthan	Chirai	150-250	25.7	250-350	Millet	Ap	0-9	82.8	8	9.2						4.9	3.1	1	0.11	1	0.24	9	1.49
					Clusterbean	A12	9-36	80	8.8	11.2						5.2	3.6		0.09	8	0.26	8.1	1.48
					Dolichos	B1	36-76	76.2	11.4	12.4						5.9	5.5		0.1	6	0.21	9.3	1.45
					Greengram	B2Ca	76-90	74.2	16.2	9.6						8.4	7.8	7	0.06	9	0.21	8.3	1.4
					Sesamum	C1ca	90-140	71.8	15.5	12.7						7.5	8	11	0.06	10	0.27	9.4	1.36
					Prosopis	C2ca	140-170	69.6	17	13.4						6.7	10.3	41	0.06	12	0.19	9.4	1.39
					Zizyphus																		
					Grass																		
Rajasthan	Pali	200-250	26.7	300-400	Pearl	Ap	0-10	46.3	35.8	17.9	1.7	9.9	5	14.7	15	13	22.8		0.37	Tr	0.44	9.1	1.49
					Greengram	A12	10-22	43.9	36.4	19.7	2.5	8.8	4.6	13	15	12.4	24	10	0.37	Tr	0.36	7.9	1.39
					Clustergram	B21	22-34	38	35.8	26.2	2.6	7.2	4.3	12	11.9	11	24.8	15	0.46	Tr	0.47	7.8	1.36
					Clusterbean	B3	34-44	38.1	33.9	28	2.3	9.9	3.8	10.2	11.9	8.1	25.8	31	0.42	7	0.53	7.9	1.39
					Horsegram																		
					Sorghum																		
					Prosopis																		
					Acacia																		
					Zizyphus																		
					Capparis																		
					Grasses																		
Rajasthan	Thar	200-250	25.9	100-290	Millet	C1	0-38	84.5	9.8	5.7		1.2	5.1	49.9	28.3				0.1	6		8	1.5
					Horsegram	C2	38-92	83.2	10	6.8	0.3	0.9	2.4	50.4	29.2				0.2	6.6		8.2	1.49
					Grasses	C3	92-108	86.1	7.4	6.8	0.2	0.7	5.6	52.3	27.3				0.1	9		8.2	1.52
					Capparis	C4	108-138	86.7	6.3	7	0.2	0.4	5.6	54.9	25.6				0.01	8.2		9.2	1.54
					Prosopis	C5	138-160	91.7	3.3	5		1	7.2	61.1	22.4				0.01	7.3		8.3	1.62
Rajasthan	Masitawali	200-250	24.9	270	Cotton	Ap	0-15	72.5	16	11.5	0.2	0.2	0.9	26.2	45	7.5	8.5		0.16	1.6	0.4	8	1.57
					Wheat	C1	15-29	65.9	15.6	18.5		0.2	0.5	28.7	36.5	7.8	7.8		0.12	1.1	0.45	8	1.57
					Sugarcane	C2	29-45	62	21.9	16.1	0.2	0.5	1.1	26.6	33.6	6.9	15		0.12	2.1	0.48	8	1.55
					Gram	C3	45-84	60.1	21	18.9	0.2	0.9	0.9	27	31.1	7	14		0.12	2.2	0.48	8.2	1.57
					Mustard	C4	84-124	70.6	16.2	13.2		0.5	0.7	33.5	35.9	4.8	11.4		0.09	7.1	0.57	8.2	1.53
					Clusterbean	C5	124-150	70.6	19.2	10.2	0.8	0.3	0.7	23.5	45.3	8.2	11	13	0.07	7.1	0.42	9.1	1.59
					Calotropis																		
					Prosopis																		
					Haloxylon																		
Rajasthan	Chomu	400-450	25	700	Millet	Ap	0-11	89.4	5.9	4.7		0.5	4.8	50	34.1				0.18	Tr	0.2	9.3	1.56
					Groundnut	A12	11-26	86.9	5.7	7.4		0.4	4.8	51.2	30.5				0.07	Tr	0.29	8.1	1.5
					Sesamum	B21	26-55	87.1	5.7	7.2		0.4	4	54.7	28				0.06		0.31	7.8	1.4
					Wheat	B22	55-87	86.8	5.3	7.9		0.4	4.7	53.4	28.3				0.04		0.31	7.7	1.37
					Barley	B3	97-119	87	5.2	7.8		0.5	4.7	53.6	28.2				0.04		0.31	7.7	1.45
					Prosopis	C1	119-155	86.4	6	7.6		0.6	4.2	52.4	29.2				0.03		0.31	7.8	1.42
					Acacia	C2	155-170	86.8	6	7.2		0.4	4.4	55.8	26.2				0.03		0.25	7.9	1.42
					Calotropis																		
					Zizyphus																		
M.P	Sarol	540-590	24.4	1050	Sorghum	Ap	0-11	13.4	30.5	56.1	1.4	1.1	0.5	0.4	10		7.3	5	0.4	0.9		8	1.92
					Pigeonpea	A12	11-29	10.6	31.5	57.9	1.8	2.9	0.4	0.4	5.1		16	5	0.34	2.7		8.1	1.87
					Wheat	A13	29-54	8.3	33.6	58.1	2.1	1.2	0.5	0.6	3.9		19	2	0.34	3.3		8.1	1.86
					Gram	A14	54-95	6	33	59	1.5	0.9	0.5	0.3	2.8		27	7	0.3	2.3		8.1	2.05
					Linseed	A15	95-119	7.9	36.6	55.5	2.7	1.2	0.6	0.4	3		23.6	5	0.3	1.9		8.1	2.05
					Acacia	A16	119-147	10	38	52	3.2	1.4	0.8	0.5	4.1		22.1	7	0.27	3.3		8.2	1.89
					Zizyphus	AC	147-160	9.4	38.1	52.5	3.4	2.1	1.1	0.3	2.5		23.4	2	0.27	14.9		8.2	2
M.P	Vaallakheri	540-580	24.4	1050	Sorghum	Ap	0-10	9.1	28.9	62	5.6	1.4	1.3	0.6	0.2		4.2		0.9	Tr		7.3	1.79

0.29	1.99	22	20	4	3.1	1.5	0.4	8	9	90	0.49	0.01	0.45	
0.7	1.25	19	15	3.2	2.5	1.2	0.7	7.6	8.9	88	0.55	0.01	0.49	
0.27	6.8	16	10	3	2.7	0.8	0.9	7.4	9.1	83	0.52	0.01	0.44	
				3.5	0.5	1	0.7	5.7	5.9	97	0.5	0.07	0.41	
				2.2	0.9	1.1	1	5.2	5.5	94	0.47	0.08	0.46	
0.19	0.78	6	7	3.5	1.5	0.5	0.4	5.9	6.1	97	0.66	0.03	0.4	
0.13	0.45	6	5	3.2	2	0.4	0.6	6.2	6.5	94	0.58	0.02	0.14	
0.15	0.36	5	4	2.6	1.5	0.5	0.5	5.1	5.9	89	0.49	0.02	0.37	
0.24	0.33	5	4	2.2	1.2	0.6	1	5	5.4	93	0.56	0.02	0.4	
0.24	0.34	7	3	2.2	1.7	0.6	0.8	5.3	5.4	100	0.43	0.02	0.55	
				2.5	1.4	0.4	0.7	5	5.9	88	0.44	0.01	0.5	
0.17	0.97	10	6	3.5	2	0.4	0.2	6.1	6.7	93	0.37	0.02		
0.17	0.97	10	6	2.9	2.9	0.5	0.2	6.5	7	91	0.35	0.02		
0.14	1.1	14	5	3.1	2.6	0.7	0.1	6.5	7.2	91	0.27	0.02		
0.21	1.09	14	5	3.8	2.6	0.8	0.1	7.3	8.1	91	0.29	0.02		
	0.7	0.8	0.3	0.3	2.1	2.3	91							
	0.7	0.9	0.4	0.1	2.1	2.2	93							
	0.9	0.8	0.5	0.1	2.3	2.4	95							
	0.9	0.8	0.4	0.1	2.2	2.6	88							
	0.9	0.6	0.5	0.4	2.4	2.5	98							
0.12	0.74	10	7	2.7	0.4	0.2	0.2	3.5		97	0.32	0.03	0.5	
0.16	0.75	11	4	2.7	0.7	0.1	0.1	3.6		92	0.22	0.02	0.45	
0.09	0.72	13	5	3.6	0.5	0.2	0.2	4.5		100	0.28	0.03	0.36	
0.06	0.67	11	5	3.2	0.6	0.1	0.1	4		94	0.23	0.03	0.41	
0.05	0.52	10	5	2.7	0.5	0.1	0.1	3.4		96	0.28	0.04	0.35	
				2.2	0.5	0.1	0.1	2.9		87	0.29	0.04	0.4	
0.3	0.4	8	19	3	1.2	0.9	0.3	5.3	5.5	96			0.3	
0.13	0.46	7	18	3.1	1.5	0.7	0.3	5.6	5.5	100			0.23	
0.11	39	10	16	3.5	2	0.7	0.5	6.7	7.1	94			0.25	
0.1	0.39	13	17	2.5	1.7	0.5	0.3	5	5.8	89			0.25	
0.1	0.3	12	17	3	1	0.7	0.3	5	6	82			0.18	
				2	2.5	0.9	0.3	5.7	5.8	98			0.31	
				3.2	1.7	0.7	0.2	5.8	5.9	98			0.38	
0.29	0.96	9	5			3.9	0.5		53.2		0.95		0.1	48.7
0.27	0.96	7	6			4.2	0.5		44.9		0.77		0.1	40.2
0.24	0.96	8	6			4.2	0.5		57.2		0.98		0.1	52.5
0.28	0.99	9	7			4.4	0.5		59.1		0.99		0.1	53.2
0.28	0.96	6	7			4.5	0.5		45.2		0.81		0.1	40.2
						4.8	0.5		49.2		0.95		0.1	43.9
						4.6	0.5		43.5		0.83		0.1	39.4
.54	3.6	49	27			1.2	0.4		62.4		1		0.16	60.8

					Gram	B1	10-21	7.8	26.6	65.6	3.4	2.6	0.6	0.3	0.6	8	2	0.84	Tr	7.4	1.79
					Pigeonpea	B2	21-38	6.3	29	64.7	2	1.6	1.6	0.8	0.9	7.3	2	0.54	Tr	7.2	1.97
					Acacia	B3	38-45	11.5	26.7	61.8	4.4	1.9	2	1.6	1.6	4.3	5	0.24	Tr	7.2	1.91
M.P	Singpura	190-220	25.7	900	Millet	Ap	0-20	59.4	10.8	29.8	0.7	0.6	0.4	2.9	54.8	6	2	0.34		7.7	
					Pigeonpea	B1	20-32	47	17.6	35.4	0.3	0.4	1.1	2	43.2	7.7		0.21		7.6	
					Wheat	B21	32-63	44.9	17.7	37.4		0.3	0.7	1.3	42.6	13.3		0.21		7.5	
					Gram	B22	63-96	42.9	17.6	39.5		0.2	0.7	1.3	40.7	15.5	2	0.21		7.[illegible]	
					Mustard	B23	96-116	45.8	16.6	37.6	0.4	0.4	0.8	2.9	41.3	13.1	2	0.2		8.1	
					Zizyphus	B3	116-155	50.7	15.5	33.8		0.2	0.5	0.9	49.1	11.1	6	0.1		8.1	
					Acacia	C	155-190	50.8	20.5	28.7		0.3	0.3	0.8	49.4	8.4		0.05		8.1	
M.P	[illegible]	[illegible]75-400	25.2	1440	Rice	Ap	0-15	13.6	22.9	63.5	2.1	1.4	1.6	3.5	5	15.2		0.52	Tr	7.[illegible]	1.67
					Wheat	A12	15-37	15.9	22.3	61.8		0.5	1.3	1.8	12.3	18.3		0.3	Tr	7.3	2.04
					Gram	A13	37-60	16.3	19.8	63.9			1.1	5.7	9.5	12.6		0.28	Tr	7.4	1.97
					Linseed	A14	60-84	17.3	19.1	63.6			1.3	6	10	7.4		0.26	Tr	7.3	1.95
					Pea	A15	84-129	15.1	20.5	64.4	0.2	1.3	1	2.1	10.5	8.4		0.25	7.9	9	1.74
					Lentil	AC	129-150	13.7	20.6	65.7			1	1.7	11	9.6		0.26	4.7	8.1	2.07
					Acacia																
					Butea																
					Annona																
					Cynodon																
					Saccharum																
M.P	Marha	[illegible]00-2[illegible]0	25.2	1330	Sorghum	Ap	0-12	11.7	44.1	44.2	0.8	1.1	1	0.7	8.1	28	4	0.48		9	1.6
					Pigeonpea	A12	12-44	9.2	43.6	47.2	1.1	1	0.8	0.7	5.6	31.8	6	0.36	Tr	8	1.9
					Wheat	A13	44-70	5.5	43.4	51.1	1	0.7	0.6	1	2.2	34		0.3	Tr	8	1.92
					Gram	A14	70-105	7	45.1	47.9	1	1	0.9	0.9	3.2	31.2		0.24	Tr	9	1.97
					Acacia	A15	105-137	5.3	49.4	45.3	1.4	1	0.7	1	1.2	36.8	3	0.24	Tr	8	1.97
						AC	137-180	10.6	49	40.4	2.3	1.1	0.8	0.5	5.9	23.3	6	0.21	2	8.1	2.31
Maharashtra	Jambha	270-370	27.2	975	Cotton	Ap	0-20	13.6	26.7	59.7	6.2	2.4	0.5	0.4	4.1		5	0.46	1.9	8.6	1.71
					Sorghum	A12	20-45	15.2	13.3	71.5	6.8	3.4	0.8	0.5	3.7		3	0.46	2.3	8.5	1.89
					Pigeonpea	A13	45-65	13.2	21.9	64.9	2.9	5.5	0.9	0.6	3.3		4	0.44	2.5	8.4	2.04
					Gram	A14	65-105	8.5	25.7	65.8	3.6	1.2	0.8	0.4	2.5		3	0.37	2.6	8.3	1.99
					Wheat	A15	105-145	8.7	18.3	73	1.3	0.5	0.4	1.3	5.2		3	0.36	1.4	8.6	1.97
					Linseed	AC	145-190	13.1	29.5	57.4	2.6	0.7	0.5	1.7	7.6		3	0.31	3	8.7	1.9
					Acacia	C	190-240	7.1	29.2	63.7	2.9	0.8	0.3	0.9	2.2		5	0.17	5.3	8.6	1.93
					Shrubs																
Maharashtra	Linga	[illegible]00-[illegible]20	27.2	1125	Cotton	Ap	0-16	4.8	20.6	74.6					4.8	12	2	0.51	1.9	8.3	
					Sorghum	A12	16-47	5.5	20	74.5	0.5				5	7	3	0.47	4	8.1	
					Wheat	A13	47-84	9.7	16.5	73.8				0.2	9.5	7.8	2	0.42	5.6	8.1	
					Pigeonpea	A14	84-117	10.3	15.1	74.6		0.7			9.6	8.6	4	0.49	6.5	8.1	
					Gram	AC	117-140	10.1	19	70.9	0.6		0.2	0.2	9	9.3	8	0.27	8.5	8.1	
					Orange																
Maharashtra	Barsi	450-500	27.1	740	Sorghum	Ap	0-12	8.6	25.5	65.9	2.6	2.5	0.3	0.7	2.5	26.6	5	0.53	0.4	8.5	1.59
					Pigeonpea	A12	12-36	7.2	28.5	64.3	1.1	1.1	2.2	0.3	2.5	21.5	5	0.52	0.4	8.4	1.52
					Groundnut	A13	36-69	7	24	69	0.1	0.1	0.2	0.3	6.3	28.9		0.5	0.3	8.3	1.7
					Safflower	A14	69-114	2.8	21	76.2	0.1		0.1	0.2	2.4	26.1		0.53	1.1	8.4	1.97
					Acacia	AC	114-147	10.3	18.6	71.1	0.5	1	1.8	2.2	4.8	1.9	6	0.39	4.7	8.4	1.83
					Zizyphus	C	147-167	18.1	23.5	58.4	2.3	1.3	3.2	4.2	7.1	47.2	10	0.26	5.2	8.2	1.69
Gujarat	Adesar		26	350	Cotton	Ap	0-8	74.6	3.5	21.9	15.1	19.2	19.8	5.7	14.8	7.7	25	0.8	0.2	8.3	
					Sorghum	B21t	8-38	56.5	7	36.5	5.8	11.3	18.5	10	10.9	7.1	29	0.4	0.4	9.6	
					Millet	B22t	38-75	48.4	11.2	40.4	8.5	8.7	13.6	7	10.6	7.5	40	0.6	2.9	8	
					Prosopis	B23t	75-127	39.3	21.4	39.3	5	7.7	6.9	8.3	11.4	6.6	33	0.8	3.6	8.9	
Karnataka	Achmatti	600	25.7	660	Cotton	Ap1	0-4	23.5	21.9	54.6	3.5	3.8	4.8	7	4.4		12	1.25	16.2	8.3	
					Sorghum	Ap2	4-22	22.3	19.1	58.6	2.8	3.4	5	7.6	3.5		12	1.21	13.6	8.6	
					Safflower	A12	22-54	13.2	18.8	68	2.5	2.3	2.4	3.5	2.5		5	1.237	12.8	8.7	

0.41	[illegible]	35	22			1.8	0.4		62.7		0.96	0.21	60.5
0.4	[illegible]	33	20			2.1	0.5		63.3		0.98	0.16	60.7
0.4	3.39	23	17			2.7	0.6		30.5		0.98	0.16	57.2
0.56	1.29	14	8			0.7	0.4		17.7		0.59	0.2	16.6
0.34	1.14	23	10			0.4	0.4		18.7		0.3	0.2	17.9
0.34	1.13	32	10			0.7	0.4		20.2		0.54	0.3	19.1
0.36	1.05	23	10			1.3	0.5		21.8		0.55	0.2	20
0.25	0.84	18	8			0.9	0.4		18.7		0.49	0.1	17.4
						1.3	0.5		17.8		0.53	0.1	16
						0.7	0.4		14.6		0.51	0.2	13.5
0.47	3.59	46	25			0.4	0.7		60.4		0.95	0.1	59.3
0.22	1.43	7	12			0.3	0.7		47.4		0.77	0.1	46.4
0.21	1.48	6	12			0.2	0.7		47.2		0.74	0.1	46.3
0.28	1.42	5	11			0.3	0.8		44.5		0.7	0.1	43.4
0.4	1.51	6	11			0.2	0.8		56.8		0.89	0.1	55.8
						0.3	0.8		53.7		0.82	0.1	52.6
0.22	0.24	5	5			1.6	0.6		48		1.09	0.1	45.8
0.77	0.65	5	6			1.1	0.6		52.2		1.11	0.1	50.5
0.21	0.68	5	6			5.4	0.3		54.4		1.06	0.1	48.7
0.25	0.71	6	6			5.4	0.8		47.4		0.99	0.1	41.2
						1.1	0.6		46.4		1.02	0.1	44.7
						1.6	0.5		47.5		1.18	0.1	45.4
0.66	0.51	10	9			0.2	1		55.2		0.92	0.17	5
0.46	1.54	10	8			0.4	0.9		49.6		0.69	0.15	48.
0.34	1.52	9	9			0.4	0.8		47		0.72	0.13	45.8
0.31	1.59	11	10			1.3	0.9		43.7		0.66	0.17	41.5
						2.8	0.9		49.7		0.69	0.2	4
						5	1		45		0.78	0.23	3
						6	1		45.3		0.71	0.23	38.
0.44	1.99	16	10			5	0.6		59.3		0.79	0.2	53.
0.22	1.74	16	11			4.6	0.6		56		0.75	0.2	50.
0.26	1.88	1	11			4.4	0.6		64.2		0.87	0.2	59.
0.26	1.85	11	11			4.8	0.6		69.4		0.93	0.2	6
						4.1	0.6		65.1		0.92	0.2	60.
0.26	1.84	7	8			1.7	0.8		70.1		1.06	0.2	67.
0.25	1.99	8	9			3.5	0.8		57.2		0.89	0.3	52.
0.2	2.32	13	10			4.5	0.8		65.4		0.95	0.35	60.
0.25	[illegible]	13	11			6.7	0.8		57.5		0.76	0.5	50.
						7.3	0.8		66.8		0.94	0.7	58.
						7.5	0.8		64.6		1.1	0.75	55.
0.26	1.57	7	17			4.2	0.7		34.8			0.23	29.
0.22	1.69	9	8			4.9	0.5		33.9			0.3	28.
0.24	1.11	5	13			2.9	0.5		33.9			0.61	30.
0.25	0.74	12	15			2.6	0.5		29.6			0.8	26.
0.21	1.09	13	8	49.5	12.6	2.4	1.1	64.6	1.09	100		0.2	
0.15	1.02	6	6	47.7	14.3	4.2	0.7	66.9	1.03	100		0.2	
0.15	1.77	6	5	46.3	22.1	10	0.7	79.1	1.05	100		1.1	

					Wheat	A13	54-87	9.8	20.7	69.5	1.4	1.7	1.8	2.6	2.2	8	0.78	15.2	8.8
					Acacia	AC1ca	87-152	9.8	20.1	70.1	1.7	1.6	1.7	2.6	2.2	13	0.71	15	8.9
					Prosopis	AC2ca	152-170	10	19.7	70.3	1.5	2	1.7	2.6	2.2	9	0.48	13.7	8.4
					Azadirachta														
Karnataka	Hungund	550-600	25.7	660	Sorghum	Ap	0-9	26.7	38.1	35.2	7	2	2.2	8.1	7.4	12	0.62	10	9.7
					Cotton	A12	9-28	23.2	17.8	59	5.6	2.3	2.1	7.2	6	9	0.66	10	8.7
					Chillies	A13	28-44	19.1	17.5	63.4	4.8	2.2	1.7	5.1	5.3	14	0.63	11	8.8
					Acacia	A14	44-70	18.1	16.8	65.1	5.5	1.9	1.5	4.3	4.9	30	0.64	10	8.9
					Neem	A3ca	70-81	18.3	17.9	63.8	8	1.8	1.3	3.2	4	41	0.57	12	9.9
					Local Grasses	Cca	81-133	39.2	30.4	30.4	22.8	6.1	4	3.4	2.9	51	0.2	25	
Karnataka	Bagalgoab	450-500	27.9	760	Sorghum	Ap	0-10	9.4	38.6	52	0.9	1.2	1.3	3.4	2.6	2	0.63	5.7	8.5
					Cotton	A12	10-50	8.2	34.5	57.3	1.3	1.1	1.2	1.7	2.9	3	0.66	5	8.6
					Safflower	A13	50-75	9.2	23.1	67.7	1.8	1.1	1.2	2.8	2.3	5	0.65	6.3	8.8
					Pigeonpea	A14	75-131	8.9	23.7	67.4	2.5	1.3	1.1	2.1	1.9	2	0.48	9	9.3
					Acacia	AC1	131-172	8.6	22.6	68.8	2.1	1.2	1.1	2.2	2	2	0.46	8	9
					Neem	AC2	172-200	9.2	19	71.8	3.1	1.4	1.1	1.8	1.8	15	0.24	9	9.3
					Prosopis														

0.24	2.22	6	4	37.7	24.5	11.3	0.7	74.2	0.97	100	
0.27	2.08	4	3	36.3	25.2	13.1	0.7	75.3	0.94	100	
				37.6	27.9	18.3	0.9	84.7	0.95	100	
0.22	1.4	9	9	42.5	11.3	1.6	0.8	56.2			
0.22	0.92	7	10	41	12.8	3.2	0.6	57.6			0.96
0.25	1.72	9	10	38.7	16.2	6.6	0.6	62.1			0.95
0.16	1.99	9	11	34.3	19	8	0.6	61.9			0.9
0.18	1.92	9	10	31.8	19.2	8.9	0.6	60.5			0.91
0.19	0.52	7	6	12.6	9.4	5.5	0.3	27.8			0.86
0.15	0.84	5	7	53.8	13.4	2.6	0.8	70.6			1.3
0.96	0.85	5	7	52.3	14.1	4.3	0.6	71.3			1.17
0.23	1.31	7	10	43.8	16.9	8.5	0.6	69.8			0.98
0.18	1.65	6	10	36.6	19.4	12.8	0.7	69.5			0.99
				39.5	17.5	10.8	0.7	68.5			0.97
				29.7	20.6	14.7	0.7	64.7			0.84

Karnataka	Raichur	750-440	27.8	750	cotton	Ap	0-12	5.5	29.9	64.6	0.6	0.9	1.1	1.4	1.5		1	0.97
					sorghum	A12	12-60	4.5	30.8	64.7	0.4	0.7	0.8	1.1	1.5		1	0.7
					Bengalgram	A13	60-112	4.3	27.5	68.2	0.7	0.8	0.9	0.6	1.3		1	0.65
					safflower	A14	112-150	4	26.7	69.3	0.4	0.6	0.7	1	1.3		2	0.53
					wheat													
					Acacia													
					neem													
M.P.	Chougel	500-600	25.7	1400	Cassia	A1	0-11	62.6	8.1	29.3	3.7	13.4	20.9	13.4	11.2	7.4	4	0.7
					sal	B21	11-34	60.3	11.6	28.1	5.3	13.7	19.5	12.1	10.6	6.8	2	0.6
					mustard	B22	34-49	61.6	10.3	28.1	3.3	11.1	17.9	14.3	15	5.4	26	0.44
					millets	B23	49-71	59.8	9.3	30.9	7.2	12.2	17.5	10.6	12.3	5.7	8	0.39
						B24tcn	71-104	47.1	10.5	42.4	8.8	11.5	10.5	6.7	9.6	5.2	31	0.41
						B25tcn	104-143	47.1	11.3	41.6	8.9	7.8	12	8.1	10.3	7.4	7	0.29
						B26cn	143-159	51.4	14.3	34.3	11.1	11.6	11.7	7.3	9.7	1.4	37	0.16
						B27cn	159-172	56.7	8.4	34.9	11.4	13	16.4	8.7	7.2	12.1	38	0.17
Karnataka	Jamkhandi	550-500	26.4	575	sorghum	Ap	0-16	73.8	6.1	20.1	11.3	26.4	19.7	12.2	4.2		3	1.03
					millet	B1	16-40	65.1	5.8	29.1	8.9	24.7	17.1	10.5	3.9		1	1.17
					cotton	B21t	40-61	47.2	14.8	38	10.3	18.2	10.5	5.7	2.5		-	1.46
					sugarcane	B22t	61-89	44	10.5	45.5	5.4	18.4	11.4	6.4	2.4		-	1.15
					maize	B31	89-123	42.8	16.3	40.9	8.5	17	9.9	5.2	2.2		1	0.77
					Acacia	B32	123-152	51.9	8.9	39.2	8.6	22.2	12.7	6.1	2.3		5	0.51
					Prosopis	IIC	152-176	59.7	9.8	30.5	28.7	12.6	10	6.2	2.2		3	0.22
					neem													
Karnataka	Bangalore	900-1000	24	750-850	millets	Ap	0-13	79.3	7.9	12.8	5.4	10.5	19.8	30.8	12.8		2	0.5
					pigeonpea	B21t	13-34	50.6	9.3	40.1	2.4	9.5	13.9	17.6	7.2		-	0.46
					groundnut	B22t	34-80	46.2	10.5	43.3	3.1	8	12.2	16	6.9		1	0.5
					Ficus	B23t	80-110	42.2	9.8	48	3.1	6.5	11.1	14.7	6.8		1	0.49
						B24t	110-160	38.5	11.8	49.7	3.8	5.9	9.2	13.2	6.4		1	0.36
Karnataka	Vijayapur	900-1000	23.6	900-1000	pigeonpea	Ap1	0-7	72.5	11	16.5	1.3	4.4	13.3	37.4	16.1		-	0.44
					Dolichos	Ap2	7-21	69.7	12.5	17.8	1.7	3.3	11.5	38.1	15.1		-	0.42
					sorghum	N21t	21-46	57.8	12.7	29.5	1.4	3.2	9.5	29.9	13.8		1	0.48
					groundnut	B22t	46-87	52	9.5	38.5	1.8	3.3	9.4	25.4	12.1		1	0.44
					Ficus	B23t	87-104	49.6	12.8	37.6	3.8	2.9	7.8	24	11.1		1	0.45
					Pogamia	IIC1	104-135	57.9	12	30.1	14.9	6.1	10.7	17.5	8.7		48	0.2
					tamarind	IIIC2	135-152	45.3	17	37.7	8.1	3.9	7.3	17.1	8.9		8	0.16
Karnataka	Channa	850-900	24	750-850	ragi	Ap	0-17	78.1	13.4	8.5	9.1	9.5	14.6	28.2	16.7		38	0.53
					pulses	B21t	17-52	41	8.7	50.3	7.6	5.4	7.2	13.2	7.6		71	0.88
					Karanj	B22t	52-87	50.8	10.1	39.1	12.8	10.1	9.1	11.7	7.1		39	0.39
					banyan	B23t	87-106	41.2	17.6	41.2	4.8	4.4	6.9	14.5	10.6		6	0.46
						B3	106-146	57.9	21.9	20.2	12.4	12.7	10.5	12.6	9.7		78	0.14
A.P.	Vadirabad	500	25.8	730	sorghum	Ap1	0-2	40.6	22.7	36.7	9.6	7.4	9.6	9.2	4.8		9	0.71
					safflower	Ap2	2-19	39.1	20.6	40.3	8.5	7.4	9.3	9.6	4.3		7	0.59
					maize	A12	19-38	35	20.5	44.5	8.1	7.2	7.7	7.8	4.2		7	0.48
					cotton	A13	38-66	30.3	22.3	47.4	7.9	5.7	6.7	6.4	3.6		13	0.47
					coriander	A14	66-86	29.1	22.1	48.8	8.6	5.4	5.8	5.7	3.6		10	0.47
					gram	ACca	86-103	37.2	19.9	42.9	15.7	6.5	5.9	5.4	3.7		17	0.4

																	0.4
3.4		9		0.53	1.27	10	7	44.5	18	1.9	1.4	65.8			1.11		
3.3		3		0.18	0.94	7	7	46.7	16.2	2.7	0.9	66.5			1.1		
3.4		9		0.1	1.14	7	8	46.2	15.5	4.2	1.3	67.2			1.05		
3.4		8		0.32	1.33	7	8	47.4	14.1	3.6	1.7	66.8			1.02		
	2.41	5.7	1.9	0.32	1.19	17	38	5	1.5	0.1	0.3	6.9	10.5	64	0.36	0.08	
	2.32	5.7	1.74	0.35	1.07	8	18	5	1.5	-	0.4	6.9	13.6	55	0.48	0.08	
	1.79	5.8	1.44	0.39	1.1	13	15	6	0.5	0.1	0.3	6.9	14.2	51	0.5	0.06	
	2.23	6	1.66	0.39	1.1	13	15	4.3	1.8	0.1	0.2	6.4	17.7	75	0.57	0.07	
	3.49	6.2	1.53	0.45	0.99	12	14	7	2.3	-	0.3	9.6	19.8	71	0.47	0.08	
	3.75	6.2	1.73					7	2.5	0.2	0.3	10	23.3	58	0.56	0.09	
	4.29	6.3	1.94					6	3	-	0.3	9.3	16.2	49	0.47	0.12	
	4.33	6.2	1.79					5	3	-	0.3	8.3	13.9	52	0.4	0.12	
1.2	0.75	8.2	-	0.43	2.23	13	14	11.3	1.8	0.3	0.9	14.3			0.82	0.04	
0.8	1.71	8.5	1.59	0.14	3.08	16	11	16.9	2.3	0.3	0.4	19.9			0.82	0.06	
1.6	2	8.2	1.68	0.14	4.52	21	11	27.3	4.8	0.4	0.5	33			0.94	0.05	
2.9	1.96	8.3	1.66	0.13	4.35	21	11	28.9	6.4	0.5	0.6	36.3			0.84	0.04	
8.4	1.69	8.6	1.37	0.17	5.16	14	9	24.8	6.7	0.6	0.5	32.6			0.86	0.03	
9.2	1.69	8.5	-					20.4	9.3	0.6	0.5	29.8			0.76	0.04	
3.9	1.89	8.2	-					15.8	8.3	0.4	0.4	24.9			0.78	0.06	
	1.92			0.33	1.32	28	19	2	0.3	0.1	0.3	2.7	2.9	93	0.23	0.15	0
	3.34		1.5	0.27	3.63	62	14	5	0.6	0.2	0.2	6	8	75	0.2	0.08	0
	3.65			0.26	3.39	35	13	6.4	0.3	0.1	0.1	6.9	8.7	80	0.2	0.08	0
	3.95		1.52	0.33	2.53	26	10	6.9	0.4	0.2	0.1	7.6	9.1	83	0.19	0.08	0
	4.22		1.53					7.3	0.2	0.5	0.1	8.1	9.4	86	0.19	0.08	0.9
		5.6		0.46	1	48	25	1.7	0.6	0.1	0.2	2.6	3	87	0.18		
		5.2		0.3	1.07	39	21	1	0.7		0.1	1.8	3	60	0.17		
		5.6	1.48	0.17	1.25	24	13	1.5	1.3	0.1	0.1	3	4.2	71	0.14		
		5.6	1.49	0.2	1.24	30	13	1.9	1.4	0.1	0.1	3.5	4.5	78	0.12		
		5.1	1.78						1.4	0.1	0.1		5.2		0.14		
		6.5						2.8	1.4	0.1	0.1	4.4	4.7	93	0.16		
		6.5						3.2	1.4	0.1	0.1	4.8	5	96	0.13		
	1.42	6.7		2.8	3.38	38	36	3.5	0.8	0.3	0.2	4.8	4.4		0.42	0.16	
	3.38	6.5	1.73	0.58	1.27	19	12	9.1	1	0.4	0.2	10.7	11.5		0.22	0.07	
	2.82	6.7	1.6	0.29	0.69	12	6	7.2	1	0.3	0.1	8.6	8.2		0.21	0.07	
	2.92	6.7	1.6	0.24	0.75	7	6	8.7	1	0.2	0.1	10	10.3		0.25	0.07	
	1.32	6.7						5.4	1	0.2	0.1	6.7	6.5		0.32	0.06	
2.2		8		0.28	1.35	15	10	34.4	2.2	0.4	0.7	37.1			1.1		
3		8.1		0.28	1.3	11	8	37	2.1	0.4	0.5	40			1.05		
3.3		8.1		0.17	1.74	11	8	39.9	3.1	0.3	0.5	43.8			1.01		
3.8		8.1		0.18	1.47	12	8	41.6	3.4	0.4	0.4	45.8			0.98		
4.4		8.2		0.23	1.45	13	9	41.9	4.7	0.5	0.5	47.6			0.98		
7.9		8.3		0.19	1.11	8	8	33.5	4.5	0.5	0.4	38.9			0.93		

					Acacia												
					neem												
A.P.	Chinnaloni	500	25.8	730	sorghum	Ap1	0-2	18	26 8	55.2	2 9	2.6	3.7	5.1	3.7	9	0.91
					chillies	Ap2	2-13	19.1	25.7	55	6.1	2.7	3.4	4.1	2.8	9	0.9
					safflower	A12	13-47	22 1	22 8	55 1	7 7	4 7	4 2	3.3	2 2	16	0 69
					Acacia												
					neem												
					palm												
					Zyzyphus												
					tamarind												
A P.	Kasreddipalli	570-550	25.8	760	chickpea	AP	0-20	23.5	22 9	53 7	4	2 2	4.3	8.6	4.4	6	0.73
					pigeonpea	A12	20-40	21.7	21.6	56.7	3.6	2.2	3.9	7.6	4.4	6	0.54
					sorghum	A13	40-60	19.5	22 1	58.4	4.4	2	3.1	6.2	3.8	6	0 47
					safflower	A14	60-90	16.2	23.7	60.1	1.5	1.9	3	5.9	3.9	6	0.39
					Acacia	AC	90-130	11.6	21	67.4	1	1.1	2.1	4.3	3.1	7	0.29
						C	130-180	12.9	20.4	66.7	2.2	1.5	2.1	3.9	3.2	9	0.25
A.P.	Patancheru	540-575	25.8	760	sorghum	Ap	0-10	73	9.1	17.9	11.5	10.3	17.8	24.3	9.1	4	0.94
					maize	A12	10-20	72.5	9.1	18.4	9.7	10.8	17.8	24.6	9.6	5	0.79
					pulses	B1	20-30	59.2	9.3	32.5	14.3	9	11.6	16.9	6.4	13	0.85
					neem	b21t	30-49	56.9	8.6	34.5	11.1	8.4	13.1	17.2	7.1	3	0 85
					Pongamia	B22t	49-102	53.1	7.4	37.5	30	6.5	6.3	6.7	3.6	37	0.48
						BC	102-145	61.9	13.8	24.3	25.3	12	9.6	9.3	5.7	15	0.23
Kerala	Thekkadi	750	27.1	4000	teak	A1	0-27	42.6	16.2	41.2	9.2	9	9.7	10.4	4.3	2	3.29
					jack	B1	27-58	41.8	15.7	42.5	13 3	7.2	8.5	9.1	3.7	3	1.43
					rosewood	B21	58-85	40.9	12.5	46.6	16.7	5.9	7.1	7.8	3.4	7	1
					shrubs	B22	85-113	38.6	16.2	45.2	14.1	5.9	6.8	7.9	3.9	8	0.87
						B23	113-143	38.3	18	43.7	14.1	5.2	6.9	8	4.1	17	0.81
						B3	143-190	48.8	11	40.2	29.7	4.6	4.9	6.2	3.4	39	0.69
Kerala	Trivandrum	60	27.1	1840	tapioca	Ap	0-9	38.5	9.9	51.6	10.4	4	6.9	10.9	6.3	42	1.39
					ginger	A12	9-25	39.9	8.7	51.4	12.1	4.4	6.9	11.1	5.4	41	1.1
					coconut	B	25-52	37.9	9.1	53	12.9	5.6	5.6	8	5.8	56	0.41
					pepper	C	52-84	34.1	13.2	52.7	9.7	5.3	5.8	7	6.3	64	0.27
					cashew												
					Eupatorium												
Kerala	Kunnamanga	50-100	27.3	3280	coconut	Ap	0-13	62.9	9.6	27.6	16.3	9.6	14.1	17.5	5.4	49	1.63
					pepper	B21	13-43	44.9	8.9	46.2	19.3	7.4	8.1	5.7	4.4	57	0.7
					tapioca	B22	43-84	42.8	11.1	46.1	16.6	7.7	7.9	7.2	3.4	59	0.66
					teak	B23	84-116	42	14	44	14.3	9.3	7.8	6.7	3.9	50	0.41
						B24	116-154	37.4	16	45.4	15.1	6.7	7.3	6.4	3.1	8	0.28
						C	154-172	35.3	20.7	42.6	8.1	8.2	9.5	7.3	3.6	14	0.19
T.N.	Palathurai	375-400	26.5	570	sorghum	Ap	0-12	75.9	10.6	13.5	4.9	9.7	16.3	24.1	20.9	1	0.66
					gram	B21t	12-39	67	12.1	20.9	6.8	9	13.6	25	12.6	8	0.74
					Acacia	B22t	39-57	64.4	12.7	22.9	7.1	10.4	13.1	16.5	17.3	21	0.81
					Prosopis	C1ca	57-68	64.4	14.1	21.5	11.2	11.1	12.6	18.6	10.9	51	0.73
					neem												
					palm												

6.2		7.8	1.55	0.4	2.23	15	8			0.6	1.5				1.12			59.9
6.2		[illegible]	1.59	0.44	2.05	13	6			0.6	1.5				1.17			58.8
9.5		7.9	1.61	0.26	1.99	11	8			0.6	0.7				1.07			57.6
[illegible]		8.9		1.27	1.17	4	5	41.7	10.9	0.9	0.7	54.2			1.06		0.09	
7.4		9.2		0.29	1.12	5	5	37.5	14.7	5.3	0.6	53.1			1.03		0.09	
[illegible]		9.4		0.26	1.06	5	5	38.4	13	2.9	0.6	54.9			0.96		0.09	
[illegible]		9.4		0.21	1.05	5	5	34.1	16.4	7.8	0.6	58.9			1		0.18	
[illegible]		9.4		0.21	1.3	5	4	30.2	18.4	12.8	0.6	62			0.93		0.45	
7.5		9.4						26.2	19.1	14.2	0.6	69.1			0.92		0.54	
	1.79	6.5						5.79	1.95	0.14	0.26	8.14	9.1		0.45	0.1		
	[illegible]	6.5						5.62	2.11	0.22	0.31	8.26	8.4		0.45	0.1		
	2.19	6.7						10.82	2.87	0.24	0.21	14.14	14.6		0.44	0.07		
	2.19	6.7						11	3.09	0.24	0.19	14.52	15.1		0.44	0.06		
	1.47	7.3						14.35	3.41	0.28	0.24	18.28	17		0.4	0.06		
	[illegible]	7						18.86	4.73	0.36	0.22	24.17	22.2					
	4.65	6		1.48	0.9	115	26	10.5	2.6	0.1	0.7	13.9	15.9	88	0.11			
	4.77	5.5		0.56	0.64	63	14	5.3	3.1	0.1	0.6	9.1	11.6	78	0.11			
	4.98	5.3		0.2	1.1	43	9	1.4	3.5	0.1	0.5	5.5	8.2	67	0.11			
	5.11	5		0.16	0.95	34	6	1.3	2.2	0.1	0.5	4.1	7.3	56	0.11			
	5.39	5						0.9	1.2	0.1	0.4	2.6	6.3	41	0.12			
	4.52	4.9						1.3	0.7	0.1	0.4	2.5	5	50	0.11			
	3.19	4.5		0.97	0.15	5	12	1.7	0.4	Tr	0.2	2.3	6.7	28	0.13	0.06		
	3.5	4.5		0.19	0.04	1	6	1	0.2	Tr	0.2	1.4	5.8	24	0.11	0.07		
	[illegible]	4.8		0.06	0.03	-	2	0.5	0.2	0.1	0.1	0.9	4	20	0.08	0.06		
	3.47	5		0.16	0.02	-	1	0.2	0.1	0.1	0.1	0.5	4.5	10	0.09	0.06		
	4.02	5.4		[illegible]	0.54	18	19	0.6	0.2	Tr	Tr	0.8	3.2	25	0.12	0.15		
	5.42	5.4		0.19	0.29	21	11	0.8	0.3	Tr	Tr	1.1	4.8	23	0.1	0.12		
	5.74	5.6		0.14	0.21	13	8	1.6	0.5	Tr	Tr	2.1	4	52	0.09	0.13		
	5.44	5.8		0.14	0.12	7	5	1.3	0.4	Tr	Tr	1.7	3.8	44	0.09	0.12		
	5.32	5.6						1.1	0.6	Tr	0.1	1.8	4.1	44	0.09	0.12		
	5.52	5.7						1	0.5	Tr	0.1	1.6	3.1	51	0.07	0.13		
2.1	[illegible]	8.4		0.26	1.28	9	15	11.8	0.6	0.3	0.2	12.9			0.96	0.08		
1.6	1.41	9.3		0.11	1.72	12	11	17.2	1.6	0.3	0.2	18.3			1.13	0.07		
2.1	1.45	8.6		0.17	2.09	13	11	18.8	1.8	0.3	0.2	21.1			1.09	0.06		
12.4	0.99	3.9		0.17	2.04	13	9	17.2	1.5	0.5	0.1	19.3			1	0.05		

T.N.	Coimbatore	275-400	25 5	570	sorghum	Ap	0-15	40.7	16.3	43	1.8	4.4	10.9	17	6.6			2	0.35
					cotton	B2	15-42	32.7	16.2	51.1	1	3	8.3	14.1	6.3			1	0.4
					pigeonpea	B3	42-75	23.6	21.7	54.7	0.8	2.2	5.7	9.6	5.3			1	0.41
					rice	Cca	75-124	23.1	21.9	55	1.1	1.7	5.3	9.3	5.7			5	0.31
					sugarcane														
					Acacia														
					Prosopis														
Bihar	Pusaro	125-500	26	1090	maize	A1	0-9	51.6	28.5	19.9	1.5	6.3	14.6	20.5	8.7	11.6	16.9	Tr	0.25
					millets	A3	9-30	43.7	29.7	26.6	1.1	6.3	13.4	16.3	6.6	13.1	16.6	Tr	0 23
					sal	B1	30-48	40.2	28	31.8	1.2	5.5	10.6	16.2	6.7	14.4	13.6	3	0.13
					teak	B21t	48-73	40.8	26.7	32.5	2.3	5.5	10.9	15.4	6.8	11.1	15.6	3	0 1
					blackberr	B22t	73-91	40.4	25.9	33.7	2.2	7.2	10.3	14.4	6.3	12	13.9	2	0.1
					jack	B23t	91-114	42.1	24	33.9	2.6	5	11 5	15.3	7.7	9.4	14 6	5	0.09
					mango	B24t	114-141	36.7	25.7	37.6	1 4	3.3	9.8	15	7 2	11.9	13.8	2	0.07
					Cynodon	B3t	141-186	33.6	25.8	40.6	1 3	3.4	11	11.7	6.2	12.2	13 6	2	0.05
					Saccharum														
Bihar	Mothiapathar	125-500	26	1090	rice	A1	0-13	31.9	52.5	15.6	0.6	2.3	6 1	13.1	9 8	24 5	28		0 59
					teak	A3	13-24	27.7	53.1	19.2	1.2	2.5	5	11.1	7.9	24.1	29		0.4
					tate	B21t	24-47	26.4	34 5	39.1	0 9	2.2	5	11	7.3	22.2	12 3		[illegible]
					jack	B22t	47-71	19.4	40.9	39.7	0.9	2.5	3.3	7 2	5.5	27 5	13.4		[illegible]
					blackberr	B23tg	71-101	25	44.3	30.7	0 7	2 2	4.6	9.7	7.8	[illegible]	[illegible]		0.1
					Cynodon	B24tg	101-127	15.8	55.5	28.7	1.1	1.6	2.7	6.4	4	29.5	26		0.1
W B.	Mrigindihi	50-100	27	1550	rice	A1	0-15	69.9	16	14.1	2.3	10.9	27.6	21.3	7.8	7.2	8.8	Tr	0.27
					wheat	A3	15-33	67.9	14.7	17.4	3	13.2	27.5	18.3	5.9	6.1	8.6	Tr	0.23
					potato	B1t	33-59	64.8	15.2	20	3.5	15.8	24.9	15.8	4.8	6.7	8.5	Tr	0.13
					cotton	B21t	59-87	60	16.9	23.1	2.8	15.3	21	15.6	5.3	6.5	10.4	Tr	0.12
					sal	B22t	87-114	62.4	14.1	23.5	6.1	14.8	23.3	13.6	4.6	6.4	7.7	1	0.12
					Acacia	B31t	114-141	60.6	16 4	23	8.2	17.3	18.9	11.8	4.4	7.4	9	1	0 1
					Heteropogon	B32t	141-165	57 4	17.4	25 2	11.5	13.4	16.5	11.7	4.3	7.5	9.9	3	0.09
					Dicanthium														
					Cyprus														
Orissa	Bhubaneswar	90-100	27	1520	rice	Ap	0-13	77.2	13.7	9.1	1.6	12.8	33.4	23.7	5.7	7.6	6.1	-	0.9
					horsegram	B1	13-27	56	28.3	15 7	1.5	8.3	20.3	19.4	6.5	18	10.3	-	0.54
					groundnut	B21t	27-50	60	20 1	19 9	2.8	11.7	20 4	18.6	6.5	14.1	6	-	0 41
					pigeonpea	B22t	50-78	54.2	24.8	21	6.4	11 7	16.4	14.1	5.6	20.2	4.6	1	0.39
					jute	B23t	78-88	43 3	42	14.7	11.1	8 4	9.5	7.4	6.9	34 8	7 2	20	0 39
					mahua														
					Butea														
					Argimona														
					Calotropis														
Orissa	Motto		27	1650	rice	Ap	0-14	43.4	17.9	38.7	3.7	7.8	13.4	13	5.5			4	0.9
					barley	A12	14-48	38.6	16 2	45.1	4	7.1	12	11.1	4.4			10	0.29
					neem	A13	48-87	27.1	16.5	56.4	2	5	8.7	7.8	3.6			9	0.21
					Ficus	AC	87-104	22.6	18.7	58.7	2	3.8	6.8	6.4	3.6			11	0.21
					Pandanus	C	104-120	24.1	17.6	58.3	2.6	4.2	7.1	6.5	3.7			12	0.11
T.N.	Valathur		26.8	870	rice	Ap	0-14	43.4	17.9	38.7	3.7	7.8	13.4	13	5.5			4	0.9
					gram	A12	14-49	38.6	16.2	45.1	4	7.1	12	11.1	4.4			10	0.29
					Acacia	A13	49-87	27.1	16.5	56.4	2	5	8.7	7.8	3.6			9	0.21
						AC	87-104	22.6	18.7	58.7	2	3.8	6.8	6.4	3.6			11	0.21
						C	104-120	24.1	17.6	58.3	2.6	4.2	7.1	6.5	3.7			12	0.11

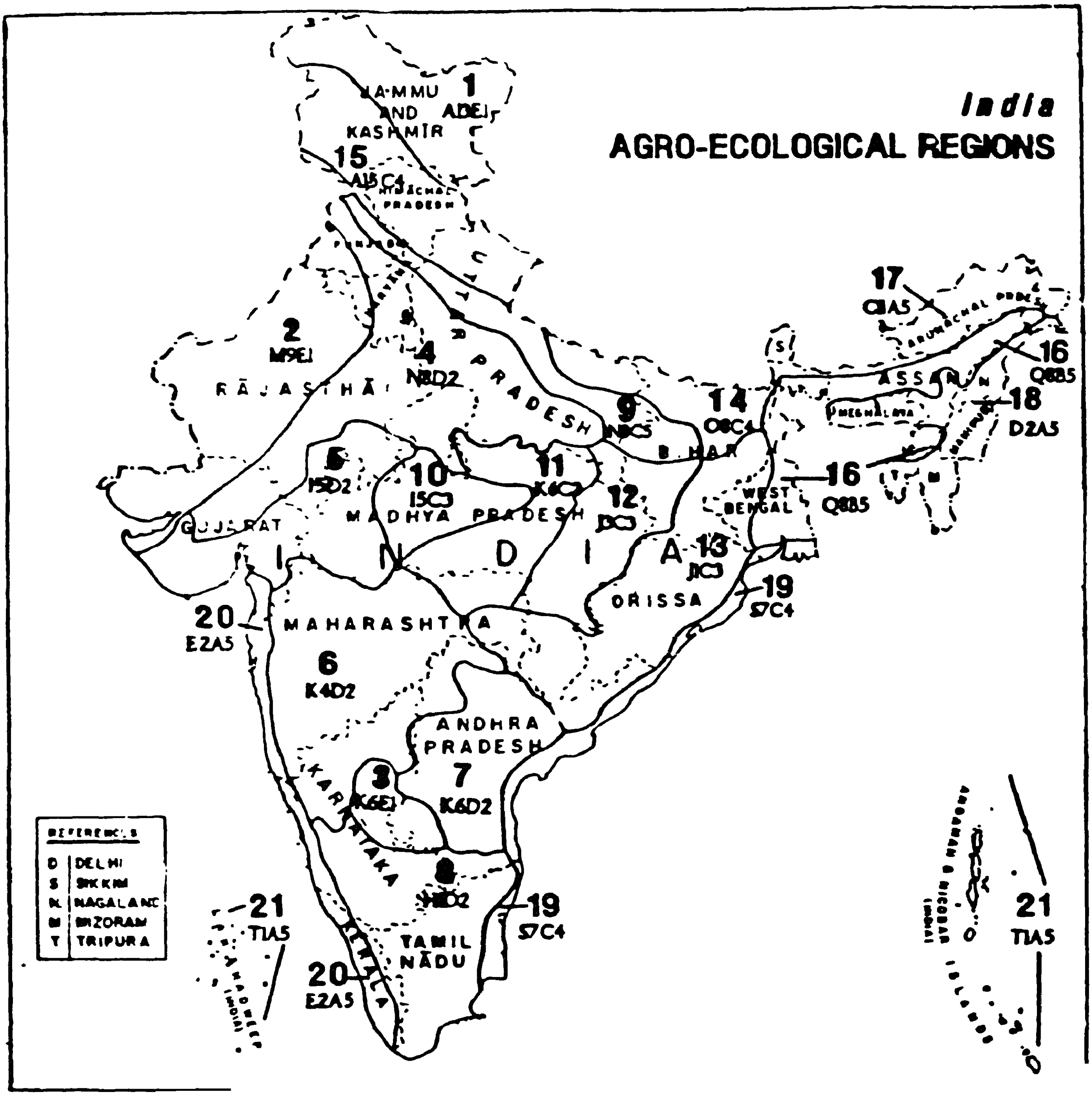
XVII

6.9		8.7		0.19	0.99	7	3	30.9	6.1	1.3	0.9	39.1	39.7	98	0.91		
9.1		9.9		0.2	1.14	7	2	34	7	3.7	0.5	45.2	50	90	0.99		
[illegible]		8.5		0.28	1.5	8	2	36.8	6.7	4.4	0.6	48.5	51.6	94	0.94		
[illegible]		3.5		0.27	1.6	6	1	30.5	9	4.5	0.6	44.6	45.1	92	0.81		
	1.16	5.1	1.81	0.2	0.75	98	20	2.4	1.6	0.2	0.5	4.7	8.5	55	0.43	0.06	
	1.44	5.5	1.65	0.12	0.55	67	14	3.6	2	0.1	0.5	6.2	8.8	70	0.33	0.05	
	2.06	6.3	-	0.14	0.41	26	7	4.4	2	0.1	0.4	6.9	9.1	76	0.29	0.06	
	2.12	6.3	-	0.15	0.37	17	5	5.6	2.4	0.2	0.4	8.6	9.6	90	0.29	0.06	
	2.18	6.5	1.62	0.17	0.42	14	5	6	2.4	0.1	0.4	8.9	10.4	85	0.31	0.06	
	2.19	6.5	-					6	2.8	0.1	0.5	9.4	11.4	82	0.34	0.06	
	2.44	6.5	-					7.2	2.8	0.1	0.5	10.6	13.3	80	0.35	0.06	
	2.56	6.3	-					6.8	4	0.3	0.7	11.8	14.3	82	0.35	0.07	
	[illegible]	[illegible]	1.74	0.46	[illegible]	56	68	4.4	1.6	0.6	0.2	6.8	12.5	54	0.8	0.02	
	4	5.4	-	0.26	0.64	[illegible]	30	4.8	1.6	0.6	0.2	7.2	12.5	59	0.65	0.02	
	[illegible]	5.5	-	0.16	0.5	12	15	8.2	2.8	0.9	0.4	12.3	17.5	70	0.45	0.01	
	[illegible]	5.5	[illegible]	0.27	0.39	11	7	8.2	2.4	0.9	0.5	12	16.4	73	0.41	0.01	
	[illegible]	5.5	1.58	0.32	[illegible]	17	8	5.6	3.2	0.5	0.5	9.8	14.8	66	0.48	0.04	
	9	5.3	-					4.4	4.4	0.6	0.6	10	15.2	60	0.56	0.04	
	[illegible]	4.9	1.63	0.19	0.25	43	14	2	0.8	0.3	0.2	3.3	5.8	57	0.41	0.05	
	[illegible]	4.9	-	0.14	0.22	56	13	2.5	0.9	0.2	0.2	3.7	6.2	60	0.35	0.05	
	[illegible]	5.2	1.59	0.12	0.29	39	9	2.9	1.2	0.2	0.2	4.5	7.6	59	0.38	0.05	
	[illegible]	5	-	0.15	0.33	35	9	2.3	1.2	0.2	0.2	3.9	8	49	0.35	0.09	
	[illegible]	5.1	1.65	0.14	0.27	28	8	3.3	1.2	0.3	0.3	5.1	8.8	58	0.37	0.09	
	1.44	[illegible]	1.73					3.6	1.6	0.3	0.3	5.8	9.2	63	0.4	0.06	
	1.14	4.4	-					4.5	2	0.3	0.4	7.2	9.6	75	0.38	0.05	
	[illegible]	4.7	1.57	0.23	0.49	40	17	2.4	0.8	0.3	0.2	3.7	6.2	37	0.68	0.03	
	[illegible]	4.8	1.6	0.4	0.51	92	13	2.8	0.8	0.4	0.1	4.1	6.8	37	0.43	0.05	
	1.44	4.9	1.6	0.12	0.48	59	10	2.4	1.2	0.4	0.2	4.2	8.4	36	0.42	0.07	
	1.05	4.9	1.56	0.12	0.46	39	8	2	0.8	0.3	0.2	3.3	8.4	28	0.4	0.05	
	2.06	4.7		0.15	0.64	36	8	2.4	0.4	0.3	0.2	3.3	9.6	27	0.65	0.14	
8.2		9.1						21.1	15.9	2.4	0.4	39.8			1.01		0.23
9.4		9.7						15	17.4	12.3	0.5	45.2			0.97		0.46
9.5		9.4						9	26.2	19.9	0.5	55.6			0.96		0.8
9		9.2						14.3	21	25	0.5	60.8			0.99		0.9
10.4		9.2						14.4	19.8	25.5	0.5	60.2			0.9		0.97
8.2		9.1						21.1	15.9	2.4	0.4	39.8			1.01		
9.4		9.7						15	17.4	12.3	0.5	45.2			0.97		
9.5		9.4						9	26.2	19.9	0.5	55.6			0.96		
9		9.2						14.3	21	25	0.5	60.8			0.99		
10.4		9.2						14.4	19.8	25.5	0.5	60.2			0.9		

Kerala	Ambalapuzha	2-5	27.3	3300	rice		0-17											4.95
					Ehinochloa		17-30											7
					Panicum		30-43											8.72
							43-60											9.56
Gujarat	Dandi		27.7	1200	Xerophytes	A11	0-2	27.9	31.1	41	0.3	0.3	0.4	0.7	26.2		-	0.65
					Halophytes	A12sa	2-17	21.5	27.3	51.2	0.5	0.3	0.3	0.3	20.1		1	0.54
						B21sa	17-53	24.2	28.8	47	0.1	0.1	0.1	0.2	23.7		-	0.49
						B22sa	53-75	28.4	22.4	49.2	-	-	0.1	2.8	25.5		1	0.47
						B3sa	75-96	28.1	25	46.9	0.2	0.1	0.4	4	23.4		2	0.49
						Csa	96-155	23.9	32.9	43.2	0.5	0.5	0.4	1.5	21		2	0.14
Gujarat	Lakhpat	60-80	26.7	350	Halophytic	A1	0-10	41.1	17.3	41.6	1.5	1.3	3.1	6.1	29.1	11	2	0.29
					Xerophytic	B21t	10-45	33.4	14.8	51.8	0.9	0.7	1.7	2.7	27.4	7.7	1	0.19
					millt	B22t	45-83	37	14.2	48.9	1.6	1.7	2.1	3	28.6	5.8	1	0.2
						B23	83-117	36.5	16.7	46.8	1.7	1.7	2.2	3.2	27.7	26.7	1	0.18
						B3	117-150	32.2	25.5	42	4	0.2	2.3	2.9	22.8	27.1	1	0.1

1.4	7.6	1.67					23.2	2.5	31.8	73	0.77	160	6.1
1.4	8	1.92					20.2	3	35.2	57	0.69	75	12
2.9	9	1.96					26.7	3.5	37	72	0.79	80	6.8
5.3	8.2	2.01					22.8	3.5	37	61	0.75	75	10.7
6.2	8.3	1.83					20.6	3.5	36.1	57	0.77	75	12
21.1	8.7	1.95					14.6	2.8	36.1	40	0.83	50	18.7
1.3	8.7		0.84	1.52	4	8	4.1	0.6	27		0.65	0.2	22.3
2.3	8.6		0.34	1.44	4	6	8.4	0.4	27		0.52	1.7	18.2
3.7	8.4		0.88	1.43	5	5	11	0.3	28.8		0.59	4.5	17.5
1.9	8.2		0.67	1.22	5	4	11.8	0.3	27.8		0.59	6.5	15.7
3.1	8.3						11.6	0.2	24.7		0.59	5.5	12.9

FIG. 4.1


India
AGRO-ECOLOGICAL REGIONS
JAMMU AND KASHMIR
1
ADE1
15
A15C4
HIMACHAL PRADESH
PUNJAB
2
M9E1
RAJASTHAN
4
N8D2
UTTAR PRADESH
9
N8C5
14
O8C4
BIHAR
17
ARUNACHAL PRADESH
16
Q8B5
ASSAM
MEGHALAYA
18
D2A5
MANIPUR
5
I5D2
10
I5C3
11
K6C3
12
J7C3
MADHYA PRADESH
GUJARAT
WEST BENGAL
16
Q8B5
INDIA
13
J1C3
ORISSA
19
S7C4
20
E2A5
MAHARASHTRA
6
K4D2
ANDHRA PRADESH
7
K6D2
3
K6E1
KARNATAKA
8
21
T1A5
19
S7C4
TAMIL NADU
KERALA
20
E2A5
21
T1A5
REFERENCES
D DELHI
S SIKKIM
N NAGALAND
M MIZORAM
T TRIPURA

India has been divided in 21 agro-ecological regions depending on various climatic and vegetative factors. Climatic factors also include geographical details of the specific regions. India is located between $68^{0}7'$ and $97^{0}25'$ east longitude and $8^{0}4'$ and $37^{0}6'$ north latitude which includes temperate tropical and sub-tropical, semi-arid, etc. zones of vegetation. Due to wide variations in climate, the variations also exist among soils from northern-most state of Jammu and Kashmir to southern-most state of Tamil Nadu and Andaman and Nicobar islands. Central parts of India have lot of desert land. Unfortunately due to mismanagement and short-term planning, total amount of deserted land is increasing in India. Productivity and fertility of cultivated land is also decreasing due to fractional input of total nutrients required by any plant for its growth and development. Deforestation has resulted in heavily eroded land over Himalayan and other hills.

Though variation in various characters of soils exist within same agro-ecological region, but National Bureau of Soil Survey and Land Use Planning has selected 21 sites as representatives of the regions and reported few characteristics of the soil from the specific sites. Various details of agro eco-region and characteristics of some typical soil series are also presented in the following table.

TABLE : 4.2

Characteristics of Some Typical Soil Series in Each Agro-ecological Region

Agro-ecoregion No. (1)	Name (Map Unit) (2)	Area (m ha and %) (3)	Physiography (4)	Climate (5)	Precip. (mm) (6)	Land Utilisation type (7)	Forest Type (8)	Dominant Soil Series (9)	Soil Taxonomy (Subgroup) (10)	Soils: Characteristics (11)	Soils: Taxonomy (12)	Clay (%) (13)	pH (1:2.5) (14)	Ec dS m^{-1} (1:2.5) (15)	^{0}C (%) (16)	$CaCO_3$ (%) (17)	CEC (cmol (p+)kg^{-1}) (18)	Ext. Acidity (19)	Ext. Fe (%) (20)	BS (%) (21)	ESP (%) (22)	Location: District (23)	Location: State (24)
1	Western Himalayas, Cold Arid Eco-Region (A13E1)	15.6 (4.7%)	Western Himalayas	Cold Arid	<150	Millets & Wheat (in Patches)	Snow Covered Most of the Time	Ladakh[5]	Typic Cryorthent[8]	Shallow, Sandy to Loamy, Skeletal Soils with Low AWC	Cryorthents, Cryorthids	8.1	8.7	0.5	0.06	2.0	8.8	-	-	100	-	Ladakh	Jammu & Kashmir
								Kibber[6]	Typic Cryorthent[8]			19.2	8.1	0.2	0.85	13.7	6.0	-	-	95	-	Keyland	Jammu & Kashmir
2	Western Plain & Kutch Peninsula, Hot Arid Eco-Region (M9E1)	29.6 (9.%)	Eastern Plain & Kutch Peninsula	Hot Arid	<300	Millets & Pulses	Tropical Thorn Forest	Pali[1]	Lithic Camborthid	Deep, Sandy & Coarse Loamy, Desert Soils with Low AWC & Deep, Loamy, Saline & Alkali Soil with Medium AWC	Camborthids, Calciorthids, Torri Passaments Natrargids	24.6	7.8	-	0.42	Tr	7.4	-	-	91	-	Pali	Rajasthan
								Thar[1]	Typic Torripsamment			6.7	8.2	-	0.08	7.6	2.4	-	-	92	-	Jaisalmer	Rajasthan
								Lakhpat[1]	Typic Natrargid			47.3	8.4	4.6	0.17	2.5	27.0	-	-	100	28	Bhuj	Gujarat
3	Deccan Plateau, Hot Arid Eco-Region (K6E1)	4.7 (1.4%)	Deccan Plateau	Hot Arid	400-500	Millets Cotton & Oilseeds	Tropical Thorn Forest	Raichur[1]	Typic Pellustert	Deep, Loamy Red Soils & Clay, Black Soils with Medium & High AWC	Chromusterts, Rhodustalfs, Ustropepts	67.4	8.0	-	0.63	3.4	71.3	-	-	94	5	Raichur	Karnataka
								Garmitta[4]	Typic Pellustert			24.8	6.3	-	0.18	-	13.1	-	-	57	-	Anantpur	Andhra Pradesh
4	Northern Plain & Central Highlands, Hot Semiarid Eco-Region (N8D2)	32.9 (10.%)	Northern Plain & Central High Lands including Parts of Gujarat Plains	Hot Semi-Arid	400-800	Millets, Wheat, Pulses & Maize	Tropical, Dry Deciduous & Thorn Forests	Kanjli[1]	Typic Ustochrept	Deep, Loamy, alluvium Derived Soils with Medium AWC & Shallow to Medium, Sandy to Loamy, Gray Brown Soils with Low to Medium AWC	Ustochrept, Ustipsamments Haplustalfs Ustorthents Ustifluvents	17.7	7.9	0.6	0.19	1.1	9.2	-	0.70	95	-	Kapurthala	Punjab
								Zarifa Viran[1]	Typic Natrustalf			30.5	9.7	3.0 (ECe)	0.17	5.7	13.5	-	-	100	84	Karnal	Haryana
								Chomu[1]	Typic Ustipsamment			6.1	7.8	0.2	0.05	-	6.6	-	-	98	11	Jaipur	Rajasthan
5	Central Highlands (Malwa) Region) & Kathiawar Peninsula, Hot Semiarid Eco-Region (15D?)	18.4 (5.6%)	Central (Malwa) Highland & Kathiawar Peninsula	Hot Semi-Arid	600-900	Millets, Wheat & Pulses	Dry Deciduous Forests	Sarol[1]	Typic Chromustert	Medium & Deep, Fine Loamy & Clay, Black Soils with Medium & High AWC	Ustochrepts, Ustorthents, Chromusterts Ustorthents	55.8	8.1	0.1	0.30	4.7	49.7	-	-	98	9	Indore	Madhya Pradesh
								Kamliakheri[1]	Vertic Ustochrept			63.2	7.2	0.2	0.54	Tr	61.9	-	-	98	-	Indore	Madhya Pradesh
6	Deccan Plateau, Hot Semiarid Eco-Region (K4D2)	33.0 (10%)	Deccan Plateau	Hot Semi Arid	600-1000	Millets, Cotton & Pulses	Tropical, Dry Deciduous & Thorn Forests	Pargaon[7]	Lithic Ustorthent	Shallow & Medium, Loamy to Clay, Black Soils with Low & Medium AWC, Inclusion of Deep, Clay Clay, Black Soil with High AWC	Ustropets, Ustorthents, Chromusterts	16.7	7.9	<0.2	0.15	30.0	20.0	-	-	100	-	Ahmednagar	Maharashtra
								Sawargaon[7]	Vertic Ustropept			39.0	7.8	39.0	7.8	0.4	0.35	34.0	40.0	-	-	Ahmednagar	Maharashtra
								Barsi[1]	Typic Ustropept			70.2	8.4	0.5	0.49	1.6	61.7	-	-	100	9	Sholapur	Maharashtra
7	Deccan Plateau & Eastern Ghats, Hot Semiarid Eco-Region (K6D2)	20.8 (6.3%)	Deccan Plateau & Eastern Ghat	Hot Semi-Arid	600-1000	Millet, Rice & Oilseeds	Tropical, Dry Deciduous & Thorn Forests	Kasireddpali[1]	Typic Pellustert	Medium, Red Loamy Soils with Low & Medium AWC, & Deep, Clay, Black Soils with Medium & High AWC	Ustropepts, Rhodustalfs, Plinthustalfs Ustorthents	61.9	9.2	0.27	0.39	6.9	59.8	-	-	100	14.0	Medak	Andhra Pradesh
								Patancheru[1]	Udic Rhodustalf			32.7	7.0	-	0.60	-	17.2	0.6	2.1	99	-	Medak	Andhra Pradesh

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
8	Eastern Plateau & Deccan Plateau Hot Semiarid Eco-Region (K1D2)	22 7 (6 9%)	Eastern Ghats (TN Uplands & Deccan Plateau	Hot Semi-Arid	600-1000	Millets, Rice, Pulses & Oilseeds	Tropical, Dry Deciduous & Thorn Forests	Tyamagondalu[1]	Oxic Paleustalf	Shallow to Deep, Loamy Red Soils, with Low to Medium AWC	Ustropepts, Haplustalfs, Rhodustalfs	45 3	6 3	-	0 45	-	8 8	0 4	3 8	81	-	Bangalore	Karnataka
								Palathurai[1]	Typic Haplustalf			21 8	8 5	-	0 76	5 4	23 4	-	1 3	84	-	Coimbatore	Tamil Nadu
9	Northern Plain, Hot Subhumid Eco-Region (N8C3)	12 2 (3 7%)	Northern Plains	Hot Sub-humid	1000-1200	Rice, Wheat, Pulses & Sugarcane	Tropical Moist Deciduous & Dry Deciduous Forests	Basiaram[1]	Typic Eutrochrept	Deep, Loamy, Alluvium-derived Soils with Medium & High AWC	Ustochrepts, Haplustalfs, Ustifluvents, Ustorthents	22 7	7 3	0 4	0 12	-	9 8	-	-	89	-	Azamgarh	Uttar Pradesh
								Haldi[1]	Typic Hapludoll			17 5	7 1	-	0 72	Tr	8 6	-	0 5	88	-	Nainital	Uttar Pradesh
10	Central High Lands (Malwa & Bundelkhand), Hot Subhumid Eco-Region (I5C3)	8 2 (2 5%)	Central Highlands Malwa & (Bundelkhand)	Hot Sub-humid	1000-1500	Wheat, Pulses & Millets	Tropical Dry Deciduous Forests	Kheri[1]	Typic Chromustert	Medium & Deep Clayey, Black Soils with Medium & High AWC	Ustochrepts, Chromusterts, Ustorthents	63 9	7 6	0 1	0 27	2 5	49 9	-	-	98	-	Jabalpur	Madhya Pradesh
11	Deccan Plateau & Central Highlands (Bundelkhand), Hot Subhumid Eco-Region (K6C3)	13 7 (4 2%)	Deccan Plateau & Central Highlands (Bundelkhand)	Hot Sub-humid	1000-1500	Wheat, Millet, Cotton & Rice	Tropical Moist Deciduous Forests	Marha[1]	Entic Chromustert	Medium, Loamy, Red Soils & Medium & Deep, Clayey, Black Soils with Medium & High AWC	Ustochrepts, Chromusterts, Ustorthents, Haplustalfs	47 9	8 0	<0 1	0 28	Tr	50 1	-	-	98	6 5	Chattarpur	Madhya Pradesh
								Linga[1]	Udic Chromustert			73 4	8 1	0 2	0 41	6 2	63 7	-	-	100	7 0	Nagpur	Maharashtra
								Dunra[8]	Udic Haplustalf			38 3	7 3	0 1	0 65	Tr	25 5	-		78	9 7	Chattarpur	Madhya Pradesh
12	Eastern Plateau (Chattisgarh Region) & Eastern Ghats (Sambalpur (Region), Hot Subhumid Eco-Region (J1C3)	13 2 (4%)	Eastern Plateau (Chattisgarh Region)	Hot Sub-humid	1200-1600	Rice, Millet & Pulses	Tropical Moist Deciduous Forests	Chutiapura[3]	Typic Haplustalf	Medium & Deep, Loamy, Red & Yellow Soils With Medium AWC	Ustochrepts, Haplustalfs, Plinthustalfs, Rhodustalfs	32 0	6 0	<0 2	0 20	-	12 6	-	-	90	-	Sarguja	Madhya Pradesh
								Chhal[2]	Udic Rhodustalf			30 9	6 2	-	0 22	-	10 4	-	-	60	-	Raigarh	Madhya Pradesh
								Ekma[2]	Typic Paleustalf			35 2	6 9	<0 2	0 15	-	14 7	-	-	89	-	Sambalpur	Orissa
13	Eastern Plateau (Chhota Nagpur Plateau) & Eastern Ghats (Sambalpur Region), Hot Sub humid Eco-Region (J1C3)	27 8 (8 5)	Eastern (Chota Nagpur) Plateau & Eastern Ghats	Hot Sub-humid	1000-1600	Rice, Pulses & Millets	Tropical Dry Deciduous & Moist Deciduous Forests	Pusaro[1]	Ultic Paleustalf	Shallow & Medium, Loamy Red Soils & Deep, Loamy Lateritic Soils with Low & Medium AWC	Ustochrepts, Ustropepts, Haplustalfs, Plinthustalfs, Rhodustalfs	33 8	6 3	-	0 11	-	11 0	-	2 2	81	-	Santhal Paraganas	Bihar
								Bhubaneswar[1]	Typic Hapludult			17 8	4 8	-	0 43	-	8 3	7 9	1 3	32	-	Puri	Orissa
								Chougel[1]	Typic Plinthustalf			34 2	6 0	-	0 38	-	17 5	-	3 0	59	-	Jabalpur	Madhya Pradesh
14	Eastern Plain, Hot Subhumid Eco-Region (O8C4)	9 3 (2 8%)	Eastern Plain	Hot Sub-humid	1400-1600	Rice, Wheat & Sugarcane	Tropical Moist Deciduous & Dry Deciduous Forests	Kesarganj[10]	Typic Ustifluvent	Deep, Loamy, Alluvium-Derived Soils with Medium & High AWC	Eutrochrepts, Udifluvents	13 1	8 9	0 24	0 23	8 0	11 3	-	-	100	-	Bahraich	Uttar Pradesh
								Sabour[9]	Aquic Hapludalf			39 4	8 1	0 33	0 33	-	-	-	-	100	-	Bhagalpur	Bihar

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
15	Western Himalayas, Warm Subhumid (inclusion humid) Eco-Region (A11C4)	17 7 (5 4%)	Western Himalayas	Warm Sub-Humid & Humid	1600-2000	Wheat, Millets, Maize & Rice	Moist Temperate Sub-tropical, Pine & Subalpine Forests	Gogji Pathar[1]	Typic Haplustalf	Shallow & Medium, Loamy, Forest & Podzolic Brown Soils With Low & Medium AWC	Eutrochrepts, Hapludalfs, Dystrochrepts,	24.0	8.1	0.7	0.23	-	13 7	-	-	98	-	Srinagar	Jammu & Kashmir
								Nahthora[1]	Mollic Haplaquept			20 5	6 9	-	0 52	1.2	5.5	-	1 2	97	-	Anantnag	Jammu & Kashmir
								Kullu[1]	Mollic Hapludalf			19 8	8.5	0 1	0 45	-	5.6	-	-	64	-	Kulu Manali	Jammu & Kashmir
16.	Assam and Bhopal Plains, Hot Humid Eco-Region (Q8B5)	11 7 (3 6%)	Assam & Bengal Plains	Hot Per-Humid	1400-2000	Rice, Jute & Plantation Crops	Tropical, Moist Deciduous & Dry Deciduous Forests	Jaihing[1]	Typic Dystrochrept	Deep, Loamy, Alluvium-derived with Medium & High AWC	Haplaquepts, Hapludalfs, Hapludulfs, Udifluvents	24.3	4 5	-	0.53	-	14 5	-	-	55	-	Lakhimpur	Assam
								Kanagarh[1]	Aeric Fluvaquent			23 6	6.6	-	0 44	-	14 6	-	0 6	92	-	Hooghpur	West Bengal
								Jorhat	Aeric Haplaquept			9 2	5 2	-	0 31	-	1 3	-	-	10	-	Jorhat	Assam
17	Eastern Himalayas, Warm Perhumid Eco-Region (C1A5)	6 0 (2 4%)	Eastern Himalayas	Warm Per-Humid	2000-4000	Rice & Millets	Sub-tropical Pine, Wet Temperate Wet Evergreen & Subalpine Forests	Gonotali[1]	Typic Hapludalf	Shallow & Medium Brown Red Hills Soils with Low AWC	Haplumbrepts, Dystrochrepts, Hapluadalfs, Hapludulfs	18 8	5 2	-	0 72	-	12.6	-	-	52	-	Siang	Arunachal Pradesh
18	North Eastern Hills (Purvachal), Warm Perhumid Eco-Region (D2A5)	10 7 (3 3%)	North Eastern Hills	Warm Per-Humid	1600-2600	Forests & rice in Patches	Wet Evergreen, Tropical, Moist, Deciduous & Wet Temperate Forests	Dialog[1]	Ultic Hapludalf	Shallow & Medium, Loamy Red, Yellow & Lateritic Soils with Low AWC	Dystrocrepts Hapludulfs, Rhodustalfs, Hapludalfs	32 9	4 4	-	0 84	-	16 1	-	-	54	-	West Manipur	Manipur
19	Eastern Coastal Plains, Hot Subhumid Eco-Region (S7C5)	8 1 (2 5%)	Eastern Coastal Plain	Hot Sub-Humid	1200-1600	Rice & Millets	Littoral & Swamp Forests	Motto[1]	Vertic Halaquept	Deep, Loamy, Coastal & Delatic Alluvial Soils with Medium & High AWC	Ustropepts, Haplaquepts, Ustifluvents	41 9	7 6	1 8	0 23	-	20 1	-	0 49	100	30 0	Baleshwar	Orissa
								Kalathur[1]	Udorthentic Pellustert			54 6	9 4	0 78	0 21	9 1	52 2	-	-	100	39 2	Thanjavur	Tamil Nadu
20	Western Ghats & Eastern Coastal Plain, Hot, Humid to Perhumid Eco-Region (E2A6)	10 1 (3%)	Western Ghats & Coastal Plains	Hot Humid Per-Humid	2000-3200	Rice Tapioca, Coconut & Millets	Tropical, Moist Deciduous Forests	Trivandrum[1]	Oxic Dystropept	Shallow and Medium, Loamy, Red & Lateritic Soils with Low AWC & Deep, Coastal Alluvial Soils with High AWC	Eutropepts, Soi- Haplustalfs, Hapludulfs, Dystrochrepts, Udifluvents	52 4	4 8	-	0 52	-	4 8	4 2[a,3]	3 4	18	-	Trivandrum	Kerala
								Kunnaman Galan[1]	Typic Haplorthox			44 8	5 6[a] 2 6[a]	-	0 45	-	4 8	0	5 5	43	-	Calicut	Kerala
21	Islands Andaman-Nicobar & Lakshadweep Groups, Hot Perhumid Eco-Region (T1S6)	0 8 (0 3%)	Islands of Andaman & Nicobar & Lakshdweep	Hot Per-Humid	1600-3000	Forest, Coconut & Rice	Tropical, Wet Evergreen Littoral Swamp Forests	Pahargaon[11]	Typic Dystrochrept	Medium & Deep, Red, Loamy & Sandy Soils with very Low to Medium AWC	Eutropepts, Dystropepts, Hapludalfs, Udipsamments	42 7	6.2	0 07	0 56	-	14 0	-	-	50	-	Austinabad Sector	South Andaman
								Garacharma[11]	Typic Troporfluvent			37 2	5 8	0 04	0 25	-	10 0	-	-	60	-	Garacharma	Andaman Nicobar
								Dhani Khari[11]	Fluventic Sulfaquent			33 2	3 6	6 3	3 9	-	9 0	-	-	45	-	Sipighat	Andaman Nicobar

So far, no properly developed soil quality criteria exists in India. Land suitability for various uses (for example, agriculture, social forestry, wastes disposal, grassland, recreation, etc.) lacks proper planning. Therefore, major fraction of land is still not used for the best suited purpose. Though one may try to do some interpretations based on data shown in the above table, but the conclusions may not be very authentic. Thorough study of constraints, landuse and potentials of the specific soil would yield some information about the quality of specific soil.

CONSTRAINTS AND POTENTIALS OF VARIOUS REGIONS

AGRO-ECOREGION 1: WESTERN HIMALAYAS, COLD ARID ECOREGION WITH SHALLOW SKETLETAL SOILS:-

CONSTRAINTS - Severe climatic limitation, viz. cryic temperature regime, which acts as a thermal pan for plant growth; Short crop growing period. Agriculture is only possible in valleys during thawing period which coincides with scanty rains; Shallow, sandy and gravelly or bouldery nature of soils; Moderately to highly calcareous. These soils pose nutrient imbalance for normal crop production.

POTENTIALS - The valley areas have great potential for dry fruit plantation crops, such as apricot, and off-season vegetables, such as peas The area under these crops has been increasing significantly; The cultivation of roses during summer (off-season for other plain areas) has greater future in this region. This can not only meet the Indian market but also has great export potential.

AGRO-ECOREGION 2: WESTERN PLAIN, HOT ARID ECOREGION WITH DESERT AND SALINE SOILS:-

CONSTRAINTS - Indiscriminate deforestation; Erratic and scanty rainfall, leading to high water deficit; Soil salinity and sodicity, resulting in physiological droughtiness; Acute droughtiness at the time of grain formation; Deficiency in N, P, Zn and Fe, resulting in nutrient imbalance.

AGRO-ECOREGION 3: DECCAN PLATEAU, HOT ARID ECOREGION WITH MIXED RED AND BLACK SOILS:-

CONSTRAINTS - High runoff and erosion hazard during stormy cloud bursts; Prolonged dry spells during crop growing period; Narrow workable soil moisture range in Black Soils; Subsoil sodicity affecting soil stucture, drainage and oxygen availability, especially in subdominant Black Soils.

AGRO-ECOREGION 4: NORTHERN PLAIN AND CENTRAL HGIHLANDS, HOT SEMIARID ECOREGION WITH ALLUVIUM-DERIVED SOILS:-

CONSTRAINTS - Coarser soil texture and low plant available water capacity (AWC); Over exploitation of groundwater, resulting in lowering of groundwater table in some areas; Imperfect drainage conditions at some places, leading to surface and subsurface salinity and/or sodicity.

AGRO-ECOREGION 5: CENTRAL (MALWA) HIGHLANDS AND KATHIAWAR PENINSULA, HOT SEMI-ARID ECOREGION WITH MEDIUM AND DEEP BLACK SOILS: -

CONSTRAINTS - Droughtiness during the intermittent dry spell periods; Imperfect drainage conditions, that limit optimum root ramification and oxygen availability in lowlying areas; Salinity and alkalinity hazards in areas under irrigated agriculture;

Severe salinity and seasonal inundation by sea water in the Kathiawar coast, resulting in crop failure;

AGRO-ECOREGION 6: DECCAN PLATEAU, HOT SEMIARID ECOREGION WITH SHALLOW AND MEDIUM (INCLUSION OF DEEP) BLACK SOILS: -

CONSTRAINTS - Prolonged dry spell periods, adversely affecting the crop growth and leading to crop failure in some years; High runoff during stormy cloud bursts in the rainy season resulting in heavy soil loss; Deficiency of N, P and Zn, leading to nutrient imbalance;

POTENTIAL - The area has high productivity potential under judicious irrigation with watershed-based management.

AGRO-ECOREGION 7: DECCAN PLATEAU AND EASTERN CHARTS, HOT SEMIARID ECOREGION WITH RED AND BLACK SOILS:-

CONSTRAINTS - High runoff during rainy season, leading to severe soil loss both in the Red and Black Soil areas; Under irrigated agriculture, unjudicious use of irrigation water and imperfect drainage conditions result in hgih ground-water table, leading to subsoil salinity and soidicity, especially in the Black Soil areas; Deficiency of N, P and Zn in soils, resulting in nutrient imbalance; Frequent drouhgtiness, resulting in crop failure in some years.

POTENTIALS - The area has high productivity potential which can be achieved when crops are grown under watershed-based management.

AGRO-ECOREGION 8: EASTERN GHATS (TN UPLANDS) AND DECCAN PLATEAU, HOT SEMIARID ECOREGION WITH RED LOAMY SOILS:-

CONSTRAINTS - High runoff, resulting in severe erosion; Coarse

soils texture and low to medium AWC, resulting in severe droughtiness during crop growth period; Nutrient imbalance, resulting from deficiency of N, P and Zn.

AGRO-ECOREGION 9: NORTHERN PLAIN, HOT SUBHUMID ECOREGION WITH ALLUVIUM-DERVIED SOILS:-

POTENTIALS & CONSTRAINTS - The area has deep loamy soils having optimum soil-air-water relationship. However, unjudicious use of irrigation wate may lead to water-logging and salinity hazards.

AGRO-ECOREGION 10: CENTRAL HIGHLANDS (MALWA & BUNDELKHAND), HOT SUBHUMID ECOREGION WITH MEDIUM AN DEEP BLACK SOILS:-

CONSTRAINTS - Narrow workable moisture which is typical of cracking-clay soils; Deficiency of N, P and Zn, resulting in nutrient imbalance; Droughtiness during dry spells in kharif season; Risk of innudation along major streams of the region, especially during crop growing period.

POTENTIALS - The soils have high potential for agricultural production when used under watershed-based management.

AGRO-ECOREGION 11: DECCAN PLATEAU AND CENTRAL HIGHLANDS (BUNDELKHAND), HOT SUBHUMID ECOREGION WITH RED AND BLACK SOILS:-

CONSTRAINTS - Cracking-clay soils with narrow workable moisture; Deficiency of N, P and Zn, resulting in nutrient imbalances; Soil erosion in most of the area and water stagnation at some places during rainy season.

POTENTIALS - The soils have high potential for agricultural production when used under watershed-based management.

AGRO-ECOREGION 12: EASTERN PLATEAU (CHHATISGARH REGION), HOT SUBHUMID ECOREGION WITH RED AND YELLOW SOILS:-

CONSTRAINTS - Susceptibility of soils to severe erosion hazards; Partial water-logging in early stages of crop growth followed by seasonal droughtiness during the rest of the period; Subsoil graveliness and coarse texture at places; Deficiency in N, P and important micronutrients, such as Zn and B, causing nutrient imbalances.

AGRO-ECOREGION 13: EASTERN (CHHOTA NAGPUR) PLATEAU AND EASTERN GHATS, HOT SUBHUMID ECOREGION WITH RED LOAMY SOILS:-

CONSTRAINTS - Susceptibility of soils to severe erosion hazard; Seasonal droughtiness, limiting optimum crop yields; Subsoil graveliness and coarse soil texture, resulting in low AWC; Deficiency of N, P and some micronutrients, such as Zn and B, causing nutrient imbalances; Moderate P fixation in some of the Red and all the Lateritic Soils.

AGRO-ECOREGION 14: EASTERN PLAIN, HOT SUBHUMID ECOREGION WITH ALLUVIUM-DERIVED SOILS:-

CONSTRAINTS - Flooding and imperfect drainage conditions, limiting soil aeration; Salinity and/or sodicity hazards, occurring in pathces; Deficiency of N, P and Zn, resulting in nutrient imbalances;

AGRO-ECOREGION 15: WESTERN HIMALAYAS WARM SUBHUMID (INCLUSION HUMID) ECOREGION WITH BROWN FOREST AND PODZOLIC SOILS:-

CONSTRAINTS - Severe climate. especially cryic/frigid termperature regime, in northern zone which limits choice of crops; Deforestation and excessive slopes, favouring soils erosion; Soil

degradation, resulting from common landslides; Imperfect drainage conditions in valleys, limiting the choice of cop to paddy; Soil acidity, especially in Kangra and Manali areas of Himachal Pradesh, resulting in P-fixation; Droughtiness, especially in the lower hills, due to excessive relief and coarser soil texture.

AGRO-ECOREGION 16: ASSAM AND BENGAL PLAINS HOT HUMID (INCLUSION SUBHUMID) ECOREGION WITH ALLUVIUM-DERIVED SOILS:-

CONSTRAINTS - Flooding and water-logging; Excessive leaching of bases and nutrients, resulting in base-status-poor soils, especially in the Bramhaputra (Assam) Valley Plain; Soil acidity resulting in plant nutrient fixation, especially P and imbalances.

AGRO-ECOREGION 17: EASTERN HIMALAYAS, WARM PERHUMID ECOREGION WITH BROWN HILL SOILS:-

CONSTRAINTS - Limiting climatic conditions, restricting the choice of crops; Steeply sloping landforms, favouring runoff and erosion losses; Shifting cultivation, leading to deforestation and severe soil erosion; Intense leaching, resulting in base-status-poor soils.

AGRO-ECOREGION 18: NORTH-EASTERN HILLS (PURVACHAL) WARM PER HUMID ECOREGION WITH RED AND LATERITIC SOILS:-

CONSTRAINTS - Shifting cultivation, leading to deforestation and severe soil erosion hazards; Excessive leaching, resulting in depletion of nutrients and low-base-status soils.

AGRO-ECOREGION 19: EASTERN COASTAL PLAIN, HOT SUBHUMID ECO-REGION WITH ALLUVIUM-DERIVED SOILS:-

CONSTRAINTS - Imperfect to poor drainage conditions, limiting oxygen supply and adversely affecting crop yields; Soil salinity (and sodicity at places), resulting from poor drainage conditions.

AGRO-ECOREGION 20: WESTERN GHATS AND COASTAL PLAINS HOT HUMID-PERHUMID ECOREGION WITH RED, LATERITIC AND ALLUVIUM-DERIVED SOILS:-

CONSTRAINTS - Excessive leaching, leading to depletion of bases and plant nutrients; Water-logging, resulting from imperfect drainage conditions in the coastal plains; Steep slopes, causing runoff and leading to severe soil erosion; Droughtiness during pre-monsoon season, resulting in poor yields; Induation of land area, resulting in saline marshes.

POTENTIALS - The area has high potential for cultivation of export-oriented plantation crops, like pepper, coffee, tea, cocoa and pineapple.

ECO-REGION 21 : ISLANDS OF ANDAMAN-NICOBAR AND LAKSHADWEEP HOT PERHUMID ECOREGION WITH RED LOAMY AND SANDY SOILS:-

CONSTRAINTS - Degradation of the tropical rain forest ecosystem, leading to severe soil erosion. When the clearing of rain forests, the ecosystem is disturbed resulting in severe soil erosion. Simultaneously economic interest to protect tropical rain forest demands introduction of sustainable plantation crops (oilpalm) by using technology which may ensure maintaining the ecosystem. It may demand deforestation in strips followed by plantation of oilpalm to provide protection against erosion. **POTENTIALS** - The

area has great potential for growing sustainable oilpalm plantation to meet the edible oil requirement of the country. But great precaution is required in deforestation the existing natural cover (in strips) and replacing these by oilpalm plantations to conserve the soils and restore the ecbsystem.

5. Waste, It's Chemistry And Soil-Waste Interactions

"We should not forget that we have inherited this earth from our ancestors and we have no right to behave with this in a manner that those who come after us find it difficult to live upon".

Pollution adversely affects everything in its periphery i.e. plant, animal, human health, comfort, amenities, air, water, land etc. In general, majority of the pollutants are result of sewage, waste, accidental discharge, by products and/or residues from production of useful products. Plant and animal protection chemicals may also cause pollution depending on their future in the environment. Many chemical are used in house, in water streams, in wells etc. for various purposes of purification and it is not made sure that they are free from creating any damage to environment . Pollutants come from only human activities whether its agricultural, industrial, domestic or tourism etc. End result is polluted air, water and soil i.e. most indispensable components for life.

Considerable work has been done on air and water pollution,. Being of equal importance land pollution should also be considered as a serious, dangerous and burning problem of today and can hardly be neglected even in future.

In preponderantly agricultural country like ours, land counts among the basic needs of the people. There are a number of competing demands on land like agriculture, forestry, grasslands,

urban and industrial (including mining) development, and transport. All such activities directly/indirectly result in harmful effects on land. Rural as well as urban areas are equally polluted, but the main sources are almost different. In rural areas the main source of land pollution is the residue of pesticides and fertilizers, crops, dirty water, etc. while in urban areas industrial waste, garbage, cans, papers, bottles and junk are dominant. Inadequate sewage system, slums and household wastes are responsible for polluting the land of both rural and urban areas. People have often assumed that anything deposited on the oil would decompose. This assumption is not quite true. Some plastics, metals, glasses and other materials will remain unchanged because there are no able soil microbes to decompose them. But soil is the closet to a universal depollutant. Most things will not rust or otherwise decompose in the soil if given enough time.

About 90 per cent of solid waste in India finds its way to dumps and landfills. Most of the remaining ten per cent is incinerated. Dumping or burying thrash on land is obviously a method of disposal with serious drawbacks. for one, it is highly limited by the amount of suitable land that is available, for the second, unless rigidly supervised and inspected, it presents a public health hazard. Even after the use of the most modern devices, incineration also has some limitations. At best, incineration reduces the amount of refuse by only 80 per cent. This process also promotes air pollution. the remaining 20 per cent, ultimately disposed off in dumps and landfills, is already accepted as injurious to public health, (and also to agricultural

crops).

Charles C. Johnson, HEW's administrator of environmental health, estimated that in the United States alone, 3,500 million metric tones of solid wastes are produced every year. Of this 360 million tones are household, municipal and industrial wastes. there are 2,000 million tones of agricultural wastes and 1,100 million tones of mineral wastes. He adds "But if it is hard to visualize garbage by millions and millions of tones, I could add that our annual throw-away includes 50,000 million cans, 30,000 million bottles and jars, 4 million tones of plastic, 7.6 million cars and trucks.: For India such reliable data have still to be gathered.

In the case of liquid wastes, there is no such thing as waste. What is discarded may be used again. The earth has a number of natural recycling systems already built in. Rain fall drains into rivers and goes to the sea where it evaporates and rises to become rain again. Science-based reclamation work has been attempted for the re-use of sewage. Remarkable results have been achieved and high sediment loads have come down and protective, productive and economic benefits have accrued. Treated sewage effluents may now be provided to farmers for irrigating crops. Experiments are also in progress to process steel from municipal waste water.

Nature has not provided a convenient model for returning the parent material in case of solid wastes, as iron to ore of plastic to petroleum. There are economic barriers also to recycling solid wastes.

The rising cost of collecting, separating and processing these materials has discouraged their re-use. Indeed, it is cheaper to dump them than to recycle them.

Table 5.1 : Generalized Treatment and Disposal Options

(Pojasek, R.B. Toxic and Hazardous waste disposal)

Potentially Hazardous Waste	Option for Adequate Health and Environmental Protection
Wastewater treatment sludges containing heavy metals	Dewatering, secure landfill; chemical treatment, secure landfill; chemical fixation, sanitary landfills
Wastewater treatment sludges containing fluorides	Secure landfill
Air pollution control ducts	Recycle (if possible); secure landfill
Air pollution control sludges	Dewatering, secure landfill
Halogenated solvents	Reclamation
Nonhalogenated solvents reclaimable, incineration	Reclamation; if not
Solvent recovery residues	Incineration, ash to secure landill; secure landfill
Degreasing solvents and sludges	Secure landfill
Organic chemical residues	Incineration; incineration with metal recovery, secure landfill
Oil refinery production wastes	Secure landfill
Leaded gasoline tank sludge	Evaporation, secure landfill
Nonleaded tank sludge	Secure landfill
Crude oil tank sludge	Secure landfill; chemical treatment, landfill
Inserts-contaminated waste	Chemical treatment, secure landfill
Coke plant ammonia waste	Secure landfill; ground sealing
Pickle liquors	Regeneration;chemical treatment, secure landfill

Pesticide wastes	Chemical treatment, secure landfill, storage
Slag scale and tailings	Secure landfill; ground sealing
Metal wastes (dry)	Recovery; secure landfill
Oil and heavy metal sludges	Oil recovery, secure landfill
Dye, chemical and pesticide containers	Rinse, sanitary landfill
Pigment, chemical and pesticide bags and packages	Incineration, ash to secure landfill
Stormwater silt from heavy industrial	Secure landfill

Table 5.2 : Physical characteristics, sanitary analyses and major constituent analyses of Pitsea leachate.
(The institution of chemical engineers symposium series no. 77. 1983).

Physical characteristics	
Colour	Peaty brown
	Paint,earthy, slightly ammoniacal
pH	8.0-8.5
Total organic carbon, TOC	200-650
Chemical oxygen demand, COD	850-650
Biochemical oxygen demand, BOD (ATU)	80-250
Ammonia nitrogen, NH_3-N	200-600
Organic nitrogen (as N)	5-20
Oxidised nitrogen (as N)	0.1-10
Alkalinity (as $CaCO_3$)	2000-2500
Phosphate (as P)	0.2
Total suspended solids (105^{o}C	100-200
Volatile suspended solids (550^{o}C)	50-100
Fatty acids, C_1 - C_6 (as C)*	20
Major constituent analyses	
Conductivity	13,700
Total dissolved solids	8,600
Total hardness (as $CaCO_3$)	1,100
Na	2,135
K	888
Mg	214
Ca	88
Cl	3,400
SO_4	340

Note : Conductivity is umho/cm; all other analyses except pH in mg/1.

* Fatty acids based on borehole and perimeter ditch analysis.

5 day BOD, with ally thiourea addition.

Table 5.3 : List of toxic dangerous substances and materials (adapted from the Council of the European Communities, 1978)

Acids and/or basic substances used in the surface treatment and finishing of metals;

Antimony and compounds

Arsenic and compounds

Asbestos

Beryllium and compounds

Biocides and phytopharmaceutical substances

Cadmium and compounds

Chemical laboratory materials, not identifiable and/or new, with unknown effects on the environment

Chlorinated solvents

Chromium (VI) compounds

Cyanide compounds

Ethers

Isocyanates

Lead and compounds

Mercury and compounds

Metal carbonyls

Organic solvents

Organohalogenated compounds, excluding inert polymeric materials and other substances referred to in this list or covered by other CEC Directives concerning the disposal of toxic or dangerous waste

Peroxides, chlorates, perchlorates and azides

Pharmaceutical compounds

Phenolic compounds

Polycyclic aromatic hydrocarbons (carcinogenic)

Selenium and compounds

Soluble copper compounds

Tarry materials from refining and tar residues from distilling

Tellurium and compounds

Thallium and compounds

In the late 1970's, a number of foreign governments decided that increased determined collaborative efforts should be made regarding the control of toxic chemicals. Such efforts were of special concern to the developing nations which lacked resources to acquire the expertise needed to solve the complex health and environmental problems caused by the use of chemicals. In May 1977, the Thirtieth World health Assembly, adopted resolution which resulted in the establishment of the International Programme on Chemical Safety (IPCS))WHO/IPCS, 1983). The resolution addressed the growing us e of chemicals due to rapid Industrialization and new technologies together with the resultant environmental pollution, as well as the increasing needs for recognition of chemical safety in the health policies of all countries. The Assembly proposed a resolution to the Director-General to study and report on the problem of concern for acute and chronic health effects on both present and releases of chemicals into the environment, resulting in adverse effects on health of epidemic proportions" 9WHO/IPCS, 1983).

In January 1979, the Director-General proposed to the Executive Board of WHO the creation of an International Programme on Chemical Safety among whose objectives would be to :

* "carry out and disseminate evaluations of the risk to human health from exposure to chemicals, based on existing information and data;
* encourage the use and improvement, and in some cases the validation of methods for laboratory testing and

epidemiological studies that are suitable for health risk evaluations; and propose appropriate methods for assessing health risks, hazards, benefits and exposure" WHO/IPCS, 1983.

Major aspects of the Programme were to include: evaluation of the adverse effects that chemicals may produce on human health; guiding principles for exposure limits to exogenous and toxic chemical substances in food, air, water, and soil; guidelines on appropriate methods for exposure measurement and assessment, toxicity testing, epidemiological and clinical studies, and risk evaluation and hazard assessment; information on dealing with chemical accidents; and case studies of past chemical accidents.

In August 1979, a meeting was held in Copenhagen on European cooperation on the control of chemicals in the environment (WHO/EURO, 1980's). Although most countries had legislation in this area, there was a need to ensure greater studies had concentrated on occupational rather than on general population hazards, more consistent epidemiological study methods were required.

Representatives from the Economic Commission for Europe (ECE), the International Labour Organization (ILO) and the Organization for Economic cooperation and Development (OECD) provided information on the activities of their organizations. All parties emphasized the importance of controlling environmental chemicals and their potential adverse health effects as the major reason for establishing the Programme. In April 1980, a Memorandum of Understanding was signed by the

executive heads of UNEP, ILO, and WHO, pledging to promote the development of the IPCS and to encourage collaboration at both national and international levels (WHO/IPCS, 1983).

An international report of the executive scientific panel on health aspects of the disposal of waste chemicals states that it is difficult to obtain information regarding chemical disposal sites and associated health effects within the developing third world. Previous reports on health problems in such countries have, for practical purposes, concentrated on communicable diseases and the need to provide clean water. However, there is a general impression that in these contours most chemical pollution especially of water, occurs from uncontrolled discharges from industrial plants and agricultural practices. From a public health viewpoint, no distinction is made between diffuse and point source pollutions such as chemical disposal sites. It must be assumed that hazardous industrial wastes are being disposed of within the community and receiving relatively little attention. This situation is under review by IPCS currently: however, action is largely one of information gathering and encouraging the implementation of preventive legislation. Due to he relatively poor public health statistics in many developing countries, it may prove difficult to relate a particular episode of illness to chemical exposure unless high-dose exposures with acute effects can be identified, as in food contamination.

A report from Sri Lanka noted that significant levels of lead poisoning exist among families engaged in gold and silver recovery from jewelers' waste (Ramakrishna et al., 1982). This indicates the potential dangers associated with cottage industries in such countries and may, in fact, prove to be of relatively much greater immediate importance than the problems caused by

chemical disposal sites from large industries. With the exception of Japan, no Asian country is known to have experienced any large-scale health hazard due to chemical waste disposal (Ichikawa, 1983).

Informed comments and views of international scientists suggest that in the Central Pacific and African regions, local practices of chemical waste disposal oare often unsatisfactory, both in relation of industrial sites, and small businesses or workshops that dispose of their untreated waste locally or through municipal disposal facilities. Apart from the Republic of South Africa, there appears to be a minimum availability of modern chemical disposal practices. At present, it is difficult to carry out any epidemiological studies regarding chronic diseases in third world countries because of the logistic and statistical problem involved. On the other hand, some illness and poisoning of an acute nature associated with toxic chemical deposits are reported. Most definite reports relate to an occupational setting of accidental poisoning where the chemical of concern has entered the food supply.

At present, more detailed analyses of the health situations in Africa, Asia, and latin America are being carried out by UNEP and the IPCS. However, no definitive reports are currently available . Health problems due to chemical waste disposal in developing countries may be more critical than believed, especially when one considers that such substances as asbestos have been disposed of without due care and control.

The practical difficulties of chemical disposal and potential health effects in East Africa and the South Pacific have been reviewed briefly (Dehl an Baumgart, 1983; UNEP, 1982). Human exposures may be occurring at higher levels than in the industrial countries. Many small accidents have occurred but since there is little or no monitoring of toxic chemicals, any adverse health effects have gone largely unrecognized. The absence of reports on adverse health effects in many developing countries is relatively meaningless due to the absence of adequate data. At the present time, identification of specific site problems would appear to be only a small part of the problem of widespread uncontrolled chemical disposal practices in which the requirements of industrial and agricultural development are a predominant force in formulating governmental policies (Dahl and Baumgart, 1983; UNEP, 1982).

LIQUID WASTES

Liquid waste, however, usually presents a different problem. While volumes of liquid industrial waste may be large and the percentage of contamination small, the major problem is the disposal of the variety of contaminants present. Industry has a historical tendency to combine all its liquid waste in a single area and subject it to a common treatment. The philosophy is found today in many large industrial complexes. It probably occurred because sanitary engineers familiar with municipal sewage systems were assigned the problem of waste disposal in the industrial plant. Since a municipal sewage system takes all sanitary sewage through a central treatment facility, a similar solution was naturally developed for the industrial facility. The point is that by handling industrial waste in this manner we often make a grave mistake. We combine a wide variety of wastes which treated individually might present simple disposal problems, but when combined they often create an insurmountable dilemma even for the sanitary engineer.

GARBAGE AND REFUSE

Basically, garbage is composed of rapidly decomposable or putrescible organic matter, mainly wastes from the preparation, cooking, and consumption of food, and wastes from the storage and sale of produce.

Refuse is a mixture of garbage and trash. Trash is decay-resistant material including metals, paper, tin cans, glass containers, leaves, rags, sweepings, hedge trimmings, plastic bags and containers, cardboard, and all kinds of miscellaneous objects.

Garbage, of course, is an extremely useful ingredient of compost a moderately efficient nitrogen source, and an excellent source of bacteria. Analysis, however, shows that only an optimistic 20 to 30 percent of municipal refuse by volume consists of garbage. Municipal refuse does not generally include food-processing wastes from canneries, slaughterhouses, and packing plants. In high-income residential communities, more food waste-particularly high-nitrogen meat waste-goes into refuse than in low-income communities. But in all communities, less home preparation of food is taking place now than went on ten years ago. As people rely increasingly on prepackaged foods and fast-food restaurants, city refuse will contain more packaging material and less garbage.

SLUDGE CHEMISTRY

Benefits to the land which result from spreading dried digested sludge are very similar to those which result from spreading garden compost. When soil is enriched with sludge, it aggregates better, holds water better, and handles air and gases like carbon dioxide better. Sludge is, in other words, a good soil conditioner.

The chief difference between sludge and garden compost is that sludge generally has a greater fertilizing value than ordinary compost. Total nitrogen concentrations in sludge range form 0.7 to 5.1 percent (dry weight); phosphorus, 1.1 to 6.1 percent; and potassium, 0.2 to 1/1 percent. On an N-P-K basis, then, sludge is usually superior to compost.

Table 5.4 : Times of Various Pathogens in the Soil and on Plants

Organism	Medium	Survival Time
Ascaris ova	soil	Up to 7 years
	vegetables	25 to 53 days
Salmonella typhosa	soil	29 to 74 days
	vegetables	31 days
Cholera vibro	spinach, lettuce	22 to 23 days
	nonacid vegetables	2 days
Endamoeba histolytica	vegetables	3 days
	soil	8 days
Coliforms	grass	14 days
	tomatoes	35 days
Hookworm larvae	soil	6 weeks
Leptospira	soil	15 to 43 days
Polio virus	polluted water	20 days
Shigella	tomatoes	2 to 7 days
Tubercle bacilli	soil	6 months
Typhoid bacilli	soil	7 to 40 days

TYPES OF INDUSTRIAL WASTE

In general, the term "industrial wastes" refers to all wastes produced on industrial premises or arising from industrial processes. These include all excess materials discarded by manufacturers as non-reclaimable or uneconomical to reclaim. They may be solid, semisolid, liquid, or gaseous. There is an almost inexhaustible number of different types of industrial wastes and, since new manufacturing processes are constantly being introduced, new wastes are continuously appearing. Wastes, however, sometimes become the raw materials of new processes. More and more industries are directing research toward finding new by-product uses.

One way of categorizing industrial wastes is to divide them into organic and inorganic groupings. By and large, inorganic wastes are not suitable for composting. In most cases they contain little or no nitrogen, and the carbon they contain is not in a form usable by microorganisms in their metabolism. There are, however, exceptions to this rule, as we will see later.

It is the organic wastes of industry that cause the problem. Water soluble organic waste may be unsuitable for landfill, because of the danger of the leaching of nitrogen and other chemicals to ground and surface waters. Organic wastes are also potential sources of infection. They can cause odors and attract pests as they decay.

On the other hand, it is organic wastes that contribute most to the soil if they are composted properly. Composting is not always the most economical way of dealing with organic wastes, but it is, except in the case of toxic wastes, the most ecologically responsible way.

Organic wastes can be further categorized into those wastes high in nitrogen and those with a low-nitrogen content. High-nitrogen wastes will decompose rapidly, but to be properly composted they must be mixed with high-carbon material at a ratio of 25 to 30 parts of carbon to one of nitrogen. Since, as we have seen in studying garden compost materials, there are; abundant sources of carbon, both in nature ;and from industry - from dried leaves or sawdust to municipal refuse- it should be easy to find complementary ingredients for waste of high nitrogen. With low-nitrogen wastes, it may be necessary to "seed" the mixture with high-nitrogen wastes such as animal manures.

Wastes of the Food Industry

In looking for high-nitrogen wastes, the first place to go is the food industry - packing houses, slaughterhouses, stockyards, fish processing companies, canneries, distilleries, dairies, and breweries.

Slaughterhouse Wastes

It has been estimated that for small slaughterhouses that do not process any by-products themselves, the compostable waste will be as much as 50 to 80 pounds on a dry basis per ton of meat processed. Large plants, which as we know, claim to use every part

of the pig but the squeal, have much less waste - an average of 25 to 40 pounds per ton. In large modern plants most of the wastes are in the form of a liquid sewage.

According to Harold B. Gotaas in his book Composting, wastes in rural slaughterhouses consist of blood, unsalable meat, intestines, offal, paunch manure (the vegetable waste found in the digestive tract of the slaughtered animal), hoofs, and other materials. He gives the following table for the content of this material:

Table 5.5

	Percent
Moisture content	75-80
Organic matter (dry basis)	80-95
Nitrogen (dry basis)	8-11
Phosphorus as P_2O_5 (dry basis)	3.0-3.5
Potassium as K_2O (dry basis)	2.0-2.5
Carbon (dry basis)	14-17
Calcium as CaO (dry basis)	3.0-3.5

In Switzerland, Beccari cell systems, are used for composting slaughterhouse wastes. These cells consist of concrete soils or pits with wall aeration and water drainage. Decomposition takes place over six months until the end product resembles stable manure in nutritional value. Beccari cell composting, which is partly anaerobic, works best for paunch manure, intestines, small pieces of meat and trimmings, while bones, hoofs, large chunks of meat, and whole carcasses are not suitable unless they are first ground.

Tankage, (the correct name for the refuse of slaughterhouses and butcher shops, exclusive of blood, which has been processed to free it of fats) has a nitrogen content of between 5.0 to 12.5 percent. The phosphoric acid content is usually around 2 percent, but it may be higher if bones are included. Gardeners can sometimes obtain tankage for addition to home compost piles. Local slaughterhouses are the best places to look for it. Blood meal or dried blood, bone meal, and hoof and horn meal which are especially rich in nitrogen may also be obtained commercially for use in home compost.

Steamed bone meal is made from green bones (those recently received from the slaughterhouse) which have been steamed or processed to remove fats. It has less nitrogen than raw bone meal. Bone black is charred bone. It is used by the sugar refining industry as a filter and is sometimes ground for sale with sugar residues in it. With the sugar residues its nitrogen content can be 2 percent. It also contains trace elements.

Wastes from the Fishing Industry

The cleanup of waste liquors and scrap produced in fish reduction processes began as a measure to control pollution, but has since become a very profitable industry in itself. Reclaimed fish solubles once thrown away now account for 20 to 25 percent of the total production value of fish products. The tobacco industry is a heavy user of fertilizers produced from fish residues, and fish emulsion fertilizer made from fish solubles is widely used by gardens. Stockwater from the wet processing to remove oil from

fish is now vacuum evaporated and the solids are used in pet foods and animal feeds. Although industry's gain is composting loss in this case, it does represent an efficient means of using waste.

Fish scrap is over 7 percent nitrogen on a dry basis, and contains almost the same amount of phosphorus. Dried ground fish is free from fat, but fish scrap contains much oil and therefore breaks down more slowly when composted. In tropical regions where citrus or banana wastes are available near fish canneries, composting of combined fish and fruit residues has been successfully carried on. It is usually done in pits because of the odor problem. Cannery fish scrap can also be used in agricultural composting. Some farmers sprinkle fish scrap with quicklime before adding it to compost to reduce problems from odor and oil. Shellfish waste is sometimes also available to farmers near processing plants.

Cannery Wastes

Dr. Golueke points out in **Biological Reclamation of Solid Wastes** that cannery waste presents problem in composting because of its high moisture content. For example, peach and apricot wastes have a moisture content of about 85 percent. He suggests incorporating these wastes with an absorbent material of porous structure which will give a balanced C/N ratio to the compost. He says:

Sawdust, straw and rice hulls can be reused repeatedly with cannery wastes because they are resistant to decomposition and can be sifted out of finished compost. Because much of the high

carbon material is removed with this method, a higher than normal C/N ratio is permissible.

A National Canners Association study suggests 1,000:1 as a permissible ratio when composting peach or apricot residues with sawdust. Nitrogen may be added in the form of manure, urea, or green vegetable matter.

Other cannery or food processing wastes which lend themselves to composting are citrus wastes, especially skins which are rich in phosphorus and nitrogen; apple pomace; asparagus trimmings; castor pomace from the making of castor oil; beet wastes from canneries or the sugar industry; coffee chaff; spinach wastes; olive residues from oil pressing; pea pods; tea leaves; spice marc; buckwheat hulls; filter cake from sugar refineries; cane waste; whey; cocoa shells; tung oil pomace; rice hulls; residues of yeast and malt companies; starch waste; and gelatin waste.

Winery Waste

The leftovers from wineries, consisting of the pressed parts of grapes, also contain yeasts and bacteria which accelerate composting. Their nitrogen content is around 1 percent. As is the case for composting cannery waste, special care must be taken to remove excess water from grape pomace before it is composted. Grape waste usually leaves the winery in sludge form. .pa

In Switzerland, grape sludge is dehydrated by means of a vibrating sieve condenser ;similar to the kind used in

sedimentation plants. To counteract the acidity of the pomace, lime is used. When the sludge is dry enough to be handled with a spade, it is mixed with an equal quantity of shredded municipal refuse and composted in large piles. Grape sludge adds much to the nutritional quality of the refuse compost and speeds its decomposition.

The following table, taken from an article by Dr. Rudolf Braun entitled, "Utilization of Organic Industrial Wastes by Composting", (Compost Science, Autumn, 1962) shares the contents of the Swiss grape sludge:

Table 5.6 : COMPOSITION OF THE SPADEABLE (DRY) AND UNFERMENTED SEDIMENTATION SLUDGE

Material	Percent
Water content	84.0
Total organic matter	70.5
Insert organic matter	17.5
Effective organic matter	53.0
Soluble humus substance	17.9
Total nitrogen	1.62
Phosphorus as P_2O_5	0.59
Potash as K_2O	0.36
Calcium as CaO	3.9
Magnesium as MgO	0.33
pH value before lime treatment	5.9
pH value before composting	7.0

A combination of pressed grapes, feathers, and hair has been composted in more than one operation in Switzerland.

Brewery and Distillery Wastes

After hops have been extracted by a process using water, the brewery leftover is called spent hops. In their wet state, spent hops are 75 percent water, 0.6 percent nitrogen, and 0.2 percent phosphorus. In the more reliable dry weight measure, nitrogen anounts to 2.5 to 3.5 percent and the phosphors about 1 percent. Spent hops are rich enough in nitrogen, and decompose rapidly enough that they make a good compost ingredient. Dried spent hops also have value as a mulch.

Some breweries will sell or donate sent hops for use in compost piles.

Another brewery waste is the material left over from the mashing process. This material, called brewers' grain, is composed of grain parts. It decays readily and contains almost 1 percent nitrogen, but it must be mixed with absorbent material to compost well. Similar grain material can be found at whiskey distilleries.

Peanut Hulls, Rice Hulls, and Soy Wastes

Peanut shells and soybean wastes are unusually high in nitrogen as compared with other vegetable by-products. Peanut shells, in fact, contain 8.6 percent nitrogen by analysis on a dry basis. Manufacturers of peanut and soy products, however, like those of fish products, now use much of what used to be waste as part of their edible products.

Rice hulls are lower in nitrogen, but they are an excellent source of potassium and they decompose rapidly in compost if a strong nitrogen source is used with them.

WASTES OF THE CLOTHING AND FABRIC INDUSTRIES

Leather Industry Wastes

The wastes from tanneries and the shoe, accessory, and leather clothing industries are particularly rich in nitrogen. Leather dust varies from 5.5 to 12 percent nitrogen, and also contains a considerable amount of phosphorus. Raw hides are as high as 13 percent nitrogen.

In France, leather waste is treated either with acid or alkaline solutions to reduce it to a form that can be used in fertilizer, or it is composted.

Tanning makes the nitrogen compounds in leather refractory and causes leather scraps to take a long time to break down when composted. Chemists at the College of Agriculture in Poona, India, found that acid treatment with 2.5 percent sulfuric acid prior to composting speeded the decomposition of both vegetable and chrome-tanned leathers in compost. With chrome-tanned leather, hydrochloric acid is also used successfully.

Tanbark is a residue resulting from the process of tanning leather by vegetable methods. In earlier times it was made from the bark of hemlock, oak, and chestnut trees. Today, when vegetable products are used in tanning, they are usually made from wattle, mangrove, myrobalans, and valonia, plants imported from

South America, Africa, India, and Asia Minor. Tannins are extracted from these plants under steam pressure. The waste material is ground, screened, dumped, composted, and sold commercially for garden use and mulching. Tanbark is moderately high in nitrogen, containing up to 1.7 percent. It is also rich in trace minerals.

Some Other Animal Wastes

· Feathers from the poultry industry are high in nitrogen - up to 15 percent - and will decompose rapidly if kept quite moist. They can be used as an absorbent with moist, but high-carbon wastes. Hair and fur are more difficult to compost because they are resistant to decay. Fine clipping or grinding and adequate moisture hasten the process.

The gelatin and glue industries which use hoof and horn material also produce high-nitrogen compostable wastes.

Animal Fiber Textile Wastes

Wool waste or "shoddy" has been used by English farmers living in the vicinity of woolen textile mills since the early days of the industrial revolution. Generally the moisture content of wool waste is between 13 and 20 percent and the nitrogen content 2 to 4 percent.

A swiss named Ernst Baumann who owned an orange plantation in Spain developed a method whereby 10 tons of woolen refuse per year were mixed with stable manure and municipal garbage and composted.

Hat manufacturers and others who make or use felt have waste composed of hair and wool which may contain up to 14 percent nitrogen. Like hair, felt requires much moisture and an abundance of bacteria to decompose quickly. Manure provide a good combining substance for composting felt waste.

Silkwarm, cocoons contain about 10 per cent nitrogen and over 1 per cent potassium. By-products from silk mills are useful in composing.

Textile Wastes from Vegetable Fibers

When we move from the wastes of animal to those of vegetable products, the high-nitrogen character of the wastes generally disappears. To achieve a proper balance for composting most vegetable wastes, we much add material of high-nitrogen content. Though more difficult to obtain, nitrogen sources are available in manure, tankage, garbage, sewage sludge, and several other wastes. There are major exceptions to the general rule that animal sources are richer in nitrogen. Cottonseed meal, peanut shells, and soy wastes, are three high-nitrogen vegetable wastes.

Cotton Wastes

Cotton textile mills produce a large amount of cotton dust, especially in their blowrooms. In India, this dust has been found to average 20 to 50 tons per year per 25,000 spindles. The waste consists of unrecoverable cotton fibers and broken cottonseed coats.

The chemical analysis is as folls, according to A.D. Bnide of the Central Public Health Engineering Research Institute, in Nagpur, India;

Table 5.7 : CHEMICAL ANALYSIS OF RAW COTTON DUST

Item	Percent by Weight
Moisture	8.0
Organic matter	70.0
Carbon	41.0
Nitrogen	1.40
Phosphorus as P_2O_5	0.60
Potash as K_2O	1.20
C/N ratio	29.28/1
pH	6.2

The table shows that the waste has an N-P-K value higher than average municipal refuse.

In India, cotton waste has been composted in large windrows under 5 feet high with a moisture range of 50 to 60 percent. The process takes 20 days with turning on alternate days. The material is sufficient clean so that it creates no nuisance in composting.

Cottonseed burrs are a source of potash. When combined with other waste products of cotton mills, they can be piled in the open and will decay to compost humus without further additions.

Cottonseed meal is made from cotton seed which has been freed from lint and hulls and has the oil extracted from it. Cottonseed cake is a rich protein food widely used in animal feeds. The meal has an acid reaction which makes it valuable for

treating alkaline soil and for use in growing acid-loving crops. Cotton seed is rich in nitrogen, containing around 7 percent.

Cottonseed hulls and hull ashes are widely used in composting and may be purchased commercially by farmers and gardeners. They are good potassium sources, containing 15 to 23 percent.

The texas State Department of Health developed a system of composting cotton gin trash which accomplishes the return to the soil of all parts of the cotton plant except the blossom and the seed. The process is comaparatively low in cost. In addition its use has almost eliminated the incineration of cotton wastes which was once a serious air polluter.

Jute and flax residues may also be composted , though preliminary water soaking may be necessary to help break down resistant fibers. Manure, sewage sludge or garbage can be used in composting these fibers, or in composting cotton wastes.

WASTES OF THE LUMBER AND PAPER INDUSTRIES

Experts have determined that there is more waste of lignin or wood fiber than of any other by-product of industry. Most of this comes from the paper and pulp mills, but the woodworking and wood-using industries such as saw-and planing-mills also contribute wood fiber waste.

Wastes of the cellulose, paper and certain industries are often in chemically treated slurry form, which contributes to difficulty in using them to compost. Some of these wastes, along

with small pieces of wood, sawdust, shavings, and ground bark, can be used in the manufacture of new products such as pressed fiber sheets and boards, and insulating materials.

Forestry also produces lignin waste from small benches, twigs, bark, chips, and sawdust. Forestry services in various countries have successfully composted this waste.

In the chapter on sewage sludge, we saw that wood chips are used in the U.S., Department of Agriculture composting projects in Beltsville, Maryland, as a high-carbon absorbent which, after being composted with sludge, can be recycled for repeated use.

The main problems with wood wastes are that their C/N ratio is extremely high and that they are resistant to bacterial action. In order to compost them, it is necessary to add an organic material with a high nitrogen content. Any material with a nitrogen level over 2 percent may be used if it is mixed in equal parts with the sawdust or wood chips. A high protein material like fish meal can be used in a ratio of one part meal to ten parts sawdust. It is also necessary to provide a ready energy source for bacteria to use before they have broken down the lignin or cellulose enough to allow it to provide their carbon. This energy source will aid in the initial breakdown of the material. Many organic materials can supply quick energy in the form of soluble sugars. Among these materials are cannery wastes, spent hops, ground pea vines or pods, garbage, or sugar beet or cane wastes.

Several wood-related industries in this country and abroad have abandoned or dismissed composting as a means of waste disposal because untreated wood scraps composted alone, even under the best conditions, may take as much as three years to produce a relatively stable humus.

In Switzerland, the time for composting wood waste has been reduced to five to six months in experiments conducted by the Swiss Federal Forestry Experimental Station and the International Research Group on Refuse Disposal. The experiments used urea or sewage sludge as a nitrogen source. Branches and leaves were chopped in small pieces, and household garbage provided an energy source and a source of bacteria. Piles were turned and re-formed at intervals.

At the University of Washington, sawdust, wood chips, and bark were experimentally composted with stable manure, sewage sludge, spent brewers' mash, and fishery refuse. A mixture of two parts wood waste to one part organic wastes proved to be most efficient.

In composting industrial wood wastes such as sawdust or wood shavings, cane sugar may be added to provide fuel for microorganisms before the carbon in the decay resistant lignin has become available to material such as bone black which has been used as a filter in sugar refining, or can or beet residue would be more practical in large-scale practice.

A group of researchers at the University of Wisconsin successfully composted sawdust in four to five weeks by treating it with gaseous ammonia and then neutralizing it with phosphoric acid. The treated sawdust was then inoculated with a particular type of fungus.

You will recall that in a compost pile it is fungi and actinomycetes that take over in the final and cooler stages of decomposition, and that these microorganisms concentrate their particular attention upon resistant cellulose and lignin materials. Though inoculums are generally ineffective, there is some evidence that inoculations of Coprinus ephemerus, a fungus that specializes in cellulose decomposition, may be effective in reducing treated sawdust. Wood materials are not natural sources of bacteria like other compost ingredients, so they may be the exception to the general rule about inoculums.

The Wisconsin experiment was conducted first in aerated barrels, then in windrows. Sawdust compost made in either manner has an exceptional ability to absorb and assimilate other nutrients.

The particle size of wood waste material is important to composting. Coarse chips take a long time to decompose, but sawdust, if too fine, tends to pack and exclude air. A mixture of shavings, chipped wood, and sawdust is most satisfactory.

WASTE OF THE CELLULOSE INDUSTRY

During the past decade, the cellulose industry has experienced tremendous expansion. This expansion has influenced not only the paper industry, but also textile, food, pharmaceutical and fermentation industries. The recovery of cellulose by chemical means has, however, created a major problem in dealing with spent wastes, particularly sulfite liquor, which is the principal waste product of cellulose extraction.

In cellulose extraction, debarked woods-usually spruce, pine, beech wood, or occasionally straw-are boiled under pressure in a calcium bisulfite solution which contains free sulfuric acid. The process dissolves the lignin out of the raw material and exposes the cellulose fiber.

When the sulfite liquor produced by cellulose extraction gets into a stream or river, it causes serious pollution problems. Schemes for using the waste, which in addition to sulfites also contains lignin, have thus far all been prohibitively expensive.

In Uzwil, Switzerland, test have been conducted using sulfite liquor as a supplement in the composting of kitchen refuse. Refuse is hammermill-ground in a municipal plant and then composted in large piles. Sewage sludge is also added if conditions require it. The sulfite liquor which is mixed with the refuse has a C/N ratio of over 300:1 and a pH of 3.0.

Piles in the project have a moisture content of 45 per cent. It has been found that the addition of spent sulfite liquor has little influence on the speed at which municipal refuse could be composted or on the physical composition of the piles, though the mass o the material was increased. The garbage, however, effectively neutralized the low pH of the liquor. The pH of the garbage was 8.6, and that of the total mixture 8.4. The finished compost had beneficial influence on the plants treated with it, an influence as good if not better than that of unmodified garbage compost.

These experiments illustrate the possibilities for cooperation between municipal composting or refuse disposal plants and the producers of industrial waste.

The following table of compostable organic wastes and their sources appeared in an article by Rudolf Braun in Compost Science.

INORGANIC WASTES

Petroleum Industry Wastes

Wastes from oil and natural gas production are usually disposed of through incineration. The industry also has many by-products for the use of primary wastes.

Russian experts have found, however, that in certain rock formations rich in oil, and in the waste products of the petroleum industry, there are substances which stimulate the growth of plants. alkaline wastes, oil slate, and bituminous rock increase the ability of soil to assimilate phosphorus and nitrogen ions and

raise the intensity of microorganism activity and biochemical process. According to Rudolf Brun of Zurich,these influences are particularly ascribed to the napthalene acids ;and mineral oils which also spur ;the development of Azotobacter and increase the antibiotic action of certain molds. In Switzerland, experiments are being conducted to find means of using these petroleum residues in composting.

CELLOPHANE AND GLASS FRIT

Research at Rutgers University has shown that waste cellophane flasks are useful as a mulch and add bulk to compost, producing a product comparable to commercially prepared peat. Cellophane is made from wood pulp, but is low in nutrients.

Agricultural experiment stations in Florida and California have found that a glass compound called frit supplies trace and minor elements to soil-sodium, potassium, iron and calcium. Neither cellophane nor frit contains enough nitrogen or available carbon to be used as active ingredients of compost, however.

STEEl BY-PRODUCTS

A waste material of steel manufacture, ferrensul, shows promise as a source of several trace minerals - calcium, sulfur, magnesium , iron, and manganese.

Basic slag is also a steel-making by-products. It comes out of the milling operation, and contains phosphorus and calcium. When composted with manure, basic slag release phosphorus and

calcium. When composted with manure, basic slag releases phosphoric acid usable by plants. Slag is alkaline in reaction. It must be ground fine before use and should be composted with acid ingredients if it is to be used on alkaline or neutral soil.

KILN DUST FROM CEMENT FACTORIES

Cement kiln dusts have about the same ability to promote yields of alfalfa and to raise the pH levels of acid soils as pulverized limestone. This was the conclusion of a study made by D.M. Carroll, C.J. Erickson, and C.W. Whittaker. Their findings indicate that cement dust can be used in place of limestone when acid wastes are composted. Like lime or powdered limestone, however, cement dust used in large quantities will drive nitrogen from compost piles as ammonia.

Another compost-related use of cement kiln dust, which was investigated at Pennsylvania State University, is in the vacuum filter processing of sewage sludge. Kiln dust was shown in experiments conducted at the University to be more effective than lime for removing water from sludge when it was used in quantities slightly larger than is normal for lime use. Additional phosphorus and magnesium in the kiln dust would also supply these nutrients to digested sludge or sludge compost.

State agricultural colleges and commercial laboratories are often willing to test industrial wastes to determine if they are suitable for composting.

Chu and Wilson (1987). Studied elution of P-dichlorobenzene through compacted soil with alcohol - water mixtures. p-Dichlorobenzene (p-DBC) was eluted through a compacted ferruginous clay with dilute aqueous solutions of methanol, ethanol, n- and i-propanaols, and n- and i-butanols. The presence of the alcohols results in very marked increases in the concentrations of p-DCB in the effluents from the clay-packed columns. Flux of p-DCB through the columns increases with increasing chain length of the alcohol, and normal alcohols increase the flux somewhat more than corresponding branched alcohols. Flux increases with increasing mole fraction of the alcohol. Flux enhancement is due almost exclusively to enhancement of the solubility of p-DCB.

Nyssen, Miller, Glass, Quinn II, Underwood and Wilson (1987). Investigated Solubilities of Hydrophobic Compounds in Aqueous-Organic Solvent Mixtures. Solubilities of several hydrophobic organic substances (paradichlorobenzene, endrin, naphthalene, and dibutyl phthalate) in aqueous solutions containing up to 0.10 mole fraction of common alcohols and ketones, were measured by gas chromatography. The solubilities are significantly increased by the alcohols and ketones. The results are interpreted in terms of the association of n molecules of alcohol or ketone with each hydrophobic organic molecule. Values of n and the equilibrium constant for this association are reported for each hydrophobic organic-alcohol and organic-ketone combination. The implications of these results for the disposal of toxic wastes by landfilling is discussed.

Sheppard, Thibault and Mitchell (1987) studied Element Leaching and Capillary Rise in Sandy Soil Cores; Disposal of hazardous wastes by burial is a common practice. This practice usually involves several barriers to the migration of the wastes, one of which is the unsaturated soil zone. The long-term consequences of capillary rise of water and its dissolved contaminants through the unsaturated soil is not easy to assess. Similarly, downward migration after a surface contamination event, such as irrigation with contaminated groundwater, is a complex process. This study examines both the leaching and capillary rise of Rc, I, Np, U, Th, Cs, Cr, and Mo through a sandy soil. Eighty undisturbed soil cores from a forest floor were contaminated, half were contaminated 10 cm from their base to simulate contact with contaminated groundwater (groundwater cores), and the other half were contaminated below the litter layer to simulate soil surface deposition (leaching cores). Cups at the base of the cores served as receptacles for groundwater or for leachate. The cores were placed in the ground with their surfaces exposed to natural rainfall. After I yr, half of the cores were exhumed. Soil moisture and temperature conditions in the cores reflected the trends of moisture and temperature at the coring site. Leachate analyses and exhumation data of the leaching cores indicated element mobility as Tc $\geq$ I>> Mo $\geq$ Cr >>> U $\geq$ Np, Cs, Th, with Tc the most mobile and Th the least mobile. Only Tc, I, Mo and Cr passed through the cores in the leachate in the first year. The groundwater cores showed that Tc, I, Mo and Cr are most likely to reach surface soils from contaminated groundwater based on one year of data. Partition coefficient (K_d) values for Tc, I, and U

from batch sorption experiments were compared with K_d values obtained from the exhumation porewater and soil, by soil horizon.

Winterlin, Schoen and Mourer (1984) studied Disposal of Pesticide Wastes in Lined Evaporation Beds. The evaporation beds used at University of California field stations provided an economical methods for on-site disposal of dilute pesticide washings created by rinsing of used containers and spray equipment. Large volumes of dilute pesticide solutions were concentrated down to more manageable levels. When the evaporation beds were used as designed, and under the conditions of this study, high pesticide residues did not tend to build up after 8 to 10 years of use. Pesticide residues did tend to concentrate in the top 0-1 inch of soil, possibly due to mass transport as the water moved toward and evaporated from the surface. Incorporating lime into the soil of the bed also appeared to accelerate the degradation of some pesticides. In order to maintain a reasonable level of safety, evaporation beds should be monitored at least once each year

Mirsatari, McChesneu, Craigmill, Winterlin and Seiber (1987) investigated Anaerobic Microbial Dechlorination; An Approach to On-Site Treatment of Toxaphene-Contaminated Soil. Enhanced microbial degradation of toxaphene by natural microorganisms occurred in soil and sediment amended with organic mater kept under anaerobic (flooded) conditions. Laboratory experiments yielded a dissipation half-life of approximately 3 and 1 week for soil and sediment, respectively, containing 10 ppm of technical toxaphene and a 1% alfalfa meal amendment. Dissipation was accompanied by an increase in early eluting gas chromatographic peaks and a decrease in later eluting peaks, indicating that dechlorination had occurred. Enhanced anaerobic dissipation also took place in soil containing 500 ppm of toxaphene, although a lesser rate than at 10 ppm, and when cotton gin waste was used as amendment in place of alfalfa meal. Sediment in a toxaphene-contaminated pesticide waste disposal ditch was amended with 10% steer manure and flooded to ascertain field utility of the technique for on-site decontamination. Toxaphene residues were reduced from 63 to 23 ppm in 120 days, and some degradation activity still occurred up to 8 months after this single treatment.

Cook (1987) reported Biodegradation of S-Triazines: An Approach To Dispose of Recalcitrant Wastes. Biological treatment of wastes, if available, is recognised as being less expensive and as producing a better-quality outflow than physico-chemical methods. Up till now, s-triazines (e.g., the herbicide atrazine) and by-products from chemical syntheses were regarded as non-biodegradable and wastes were usually treated physically. We have developed analytical HPLC methods to identify and determine routinely the whole range of by-products (e.g., N,N′-bis(ethyl)-N′′-(1-methylethyl)-1,3,5-triazine-2,4,6-triamine and -chloro-4-ethylamino-1,3,5-triazine-6(5H)-one) in wastes from these syntheses. We have also obtained aerobic cultures (e.g., Pseudomonas spp.) that quantitatively utilize the by-products as sole sources of nitrogen for growth. Biochemical pathways of catabolism have been elucidated and no toxic intermediates seem to be involved. A mixed culture has been used to treat real wastes from herbicide syntheses under non-sterile conditions and about 80% conversion of s-traizines to cell material was observed. Small scale (2 and 25 l) fludised beds were constructed. The main problems encountered were the costs of the carbon source and oxygen and the low rates of some enzymes.

Heida studied Soil Sediment and Water Contamination As A Result of Chemical Waste Incineration. The data obtained so far demonstrate convincingly that the former chemical waste incineration site located on the outer dike area along the Ijmeer shore east of Amsterdam, appears to be seriously contaminated with many chemical compounds of a most diverse nature, including the highly toxic 2,3,7,8-TCDD-congener as well as related PCDD's and PCDF's. In many respects the Diemerzeedijk dump-area closely resembles the soil and sediment contaminationfound in the Volgermeerpolder refuse dump-site described elsewhere. The findings also produce evidence of groundwater contamination in the proximity of the incineration site. Moreover, ongoing soil particle wash-out and movement of phreatic groundwater, together with soot particle deposit and surface flow-down of liquid incineration residuals in the past, have caused contamination of adjacent IJmeer sediments. However, the incineration site cover of coal fly ash still provides sufficient protection for the environment, thus preventing exposure to both humans and wildlife.

Schoen and Winterlin (1987) reported The Effects of Various Soil Factors and Amendments On The Degradation of Pesticide Mixtures. Soil disposal is the most common method of handling dilute pesticide wastes. The effects of several soil factors on the degradation of a pesticide mixture were investigated. Atrazine, captan, carbaryl, 2,4-D, diazinon, fenitrothion, and trifluralin were studied under varying laboratory conditions of soil type, pH, moisture content, organic matter content, microbial activity, and pesticide concentration. Of the variables investigated, pesticide concentration was the single most important factor with degradation rates much slower at high (1000 ppm) levels of fortification than moderate (100 ppm) levels. Under most conditions, chemical degradation was at least as significant as microbial degradation. Effects of other factors varied considerably and were pesticide dependent.

Hodapp and Winterlin (1989) investigated Pesticide Degradation in Model Soil Evaporation Beds.

A = *Acid Treatment* O = Added Organic Matter
L = Lime treatment Z = Added Zinc
N = Natural Soil C = Control

Percent degradation after 54 weeks. Refer to Figure 2 for an explanation of treatments.

Treatment	Diazinon	Ethyl Parathion	Propazine	Thiodan	Trifluralin
AEROBIC BEEDS					
A	49.58	34.74	35.99	49.09	50:64
L	77.75	69.83	75.59	78.01	75.94
N	62.54	45.45	47.97	61.03	55.10
AO	72.19	63.20	64.46	71.18	64.97
LO	53.47	43.99	41.08	53.53	52.89
NO	66.45	57.77	63.47	65.30	63.92
AZ	62.58	49.21	58.01	60.67	52.81
LZ	48.76	40.44	37.11	50.93	42.87
NZ	65.62	44.23	61.90	56.22	46.16
AOZ	59.27	24.30	50.08	49.72	32.99
LOZ	48.99	27.12	55.30	51.41	40.42
NOZ	59.01	44.92	60.35	59.77	46.54
ANAEROBIC BEDS					
A	31.63	13.37	5.66	35.89	21.74
L	71.42	44.64	37.75	60.69	48.96
N	71.55	54.33	58.41	82.58	55.16
AO	72.35	48.40	53.89	65.22	53.75
LO	79.79	67.58	59.96	72.31	62.93
NO	47.95	30.98	31.44	50.97	37.47
AZ	46.75	18.60	17.28	36.20	29.51
LZ	50.94	29.73	34.37	44.77	38.01
NZ	64.85	27.60	64.28	43.91	35.86
AOZ	41.38	11.82	54.02	28.66	19.13
LOZ	75.19	45.45	75.12	60.90	54.20
NOZ	92.80	72.68	70.79	55.13	49.65

Eduljee, Badsha and Price (1985) conducted three studies on Environmental Monitoring For PCB and Heavy Metals In The Vicinity Of A Chemical Waste Disposal Facilities. As part of a long-term environmental monitoring programme, PCBs and heavy metals have been determined on a monthly basis in soil and foliage samples collected from 13 sites, generally located within a 2 Km radius of a hazardous and toxic waste disposal facility that has been operating for over ten years. Data are presented for a seven month period, from June 1984 to December 1984, and the results compared with normal worldwide background values given in the literature, and with some isolated U.K. samples. The comparison showed that no elevations indicative of industrial pollution had occurred. A statistical evaluation of the data indicated that there was no correlation suggestive of an airborne mode of transportation from a point source, with respect to distance from the plant or to the predominant wind vectors. The results confirm that the waste disposal facility has had no detrimental effect on the environment.

PCB and trace metal data are reported for soil and grass samples collected over a the period July 1984 to January 1985, and in March and June 1985, at 13 sites within a 3.5 Km radius of a hazardous and toxic waste disposal facility in Bonnybridge, Scotland. Transient elevations in trace metal levels were observed over the whole of the sampling area, unconnected with a point source in Bonnybridge, and suggests that the area is impacted by air-borne material from external sources. While PCB levels within the sampling area were consistent with background levels observed elsewhere, other investigators have measured

transient elevations in soil samples collected 1 to 4 Km west of the perimeter of the sampling area, again indicative of external influences. However, even the highest concentrations found in this region appear to be well below the levels at which PCBs, when fed to cattle, have been shown to produce no adverse effects.

A long-term environmental monitoring programme was instituted in the vicinity of a hazardous waste disposal facility. The programme involved the analysis in soil and grass from pre-selected sites, of a range of metals, and of PCB. A statistical analysis of the results for the period August 1984 to March 1086 indicates that the study area is not affected by significant point source emissions within its boundaries. Concentrations of PCBs and trace metals are generally within background levels established for other locations.

Johnson etal. (1985) Migration of Chlorophenolic Compounds at the Chemical Waste Disposal Site at Alkali Lake, Oregon - 2> Contaminant Distributions, Transport, and Retardation. The area distributions of eight chlorinated phenolics hydraulically downgradient from a chemical disposal site have been presented. These results show, for the first time, well-behaved concentration contours embodying compound dependent retardation in the transport of sorbing and nonsorbing organic compounds from an existing waste disposal site. The trends in relative retardations of the compounds are consistent with the K_p values determined in batch equilibrium experiments carried out using samples of the native soil and ground water (pH- 10).

While the trend in observed retardations of the chlorophenolics is correct, the magnitudes of the relative retardations are less than those predicted using K_p values determined from the batch experiments. This is probably the result of irregularities in the K_h values downgradient of the site. Cosolvent effects due to the plume itself, nonuniform contaminant distributions, and the fractures in the aquifer are believed to have played only a minor role in this regard.

Pinkowski etal. (1982) conducted a study of Liquid Livestock Waste Disposal on a Forested Watershed in Southern Illinois: Effects on soil. This study showed the importance of monitoring the quantity of effluent discharged into a forested watershed. As long as its filtering capacity is not exceeded, a forested watershed can use the nutrients in feedlot runoff. If the watershed's filtering capacity is exceeded, however, salting in of the soil profile, decreased plant survival, and poor water quality may result.

Weeks, published a paper on review of the evolution of liner design for hazardous waste landfills since the first RCRA regulations in 1980. We have also presented a discussion of different approaches used in meeting recent minimum technology requirements. The use of composite clay/synthetic membrane liners seems prudent in implementation of these standards. In some cases, prefabricated bentonite meeting may be used as a soil. component in a composite liner system.

Daniel and Brown studied Landfill Liners: How Well Do They Work and What is Their Future? In the U.S., liners for hazardous waste disposal facilities usually consist of two flexible membrane liners (FML's) underlain by a compacted, earthen liner. There have beennumerous failures of both FML's and earthen liners, but most of the failures appear to have been used by faulty design and/or construction. While it may be possible to build successful liner systems, careful design of liners and extraordinary construction quality assurance are needed.

Brown and Thomas Workedon: New Technology for Liners. Currently available technologies for the containment of waste include the use of compacted clay liners and flexible membrane liners (FMLs). Laboratory measurements of clay liner conductivities generally underestimate field values. In addition, the bulk density of the compacted soil does not appear tobe a good predictor of conductivity. Therefore all liners should be field tested for conductivity prior to use. Research indicates that minimal conductivity can be achieved through the use of very thin lifts plus lime or cement additives. Treatment of clays with quaternary ammonium compounds also shows promise as a means of retarding the movement of organic contaminants through compacted clays.

A strict construction quality assurance plan is critical to minimize flaws in the FML. In addition, the conductivity of the liner material to the organic components of the waste needs to be determined prior to use. The dangers of placing containerized liquids or solidified liquids in facilities if discussed. The use of vapour extraction systems between FMLs and the use of gravity drained above ground storage mounds as innovative means for minimizing the potential for future soil and water contamination is reviewed.

Brown investigated Use of soils to retain waste in landfills and surface impoundments Soil lined facilities have been used extensively for the containment and disposal of waste liquids. Often slowly permeable natural clay-rich deposits were relied upon to retard the movement of liquids from landfills or surface impoundments. In some cases, remolded layers of soils with laboratory hydraulic conductivities of 10^{-7} cm s^{-1} or less have been constructed with the intention of retaining liquids. There is an increasing body of data which indicates that the hydraulic conductivity of both in site clay deposits and recompacted clays may be greater than those measured on samples in the laboratory. In addition, these facilities have received a wide range of waste liquids with properties that differ greatly from those of water. In fact, most of the waste liquids which have been disposed in landfills are nonaqueous.

Water is well known for its ability to hydrate clay soils and cause them to swell, resulting in low conductivities. Many organic liquids are known to cause the interlayer spacing of smectitic clays to decrease from those which occur when the same clay is wetted with water. Thus, organic liquids could possibly cause hydrated clay-rich soils to shrink and crack, which could result in an increase in the conductivity of the soils intended to retain organic liquids.

A theoretical evaluation of the influence of dielectric properties of liquids on the thickness of the double layer between adjacent clay minerals are hydrated with liquids having dielectric constants lower than that of water. Most common organic liquids have dielectric constants considerably lower than that of water,

suggesting that they should cause hydrated soil to shrink. X-ray observations of a smectitic clay mineral wetted with organic liquids confirmed that the interlayer spacings were less than those observed when the clay was wetted with water. Electrophoretic mobility studies indicated that organic liquids with low dielectric constants cause suspended clay to fl9occulate. Flocculation studies using dispersed clays indicated that smectitic, micaceous, and kaolinitic clays all flocculated rapidly when they were added to organic liquids, which had low dielectric constants and which were only sparingly soluble in water. The clays also flocculated when placed in a solution containing greater than 50% water soluble organic liquid. Observations of bulk samples of the three above mentioned clays indicated that water wetted speciments swelled more than similar samples wetted with organic liquids.

Laboratory studies of conductivities using a range of organic liquids including both polar and nonpolar solvents, waste solvents, and commercial petroleum products indicated that the hydraulic conductivities of compacted soils to organic liquids were one to five orders of magnitude greater than those of water. Observation of the soils permeated with dye labeled organic liquids revealed the formation of platy structural units near the surface. The dye stains in the soil revealed that the organic liquids moved through cracks that penetrated the soil, which originally had a massive structure. Field test cell liners were constructed using three clays and two organic waste liquids. The conductivity measurements in the test cells confirmed the

laboratory findings. The nonpolar solvent waste containing xylene which was used to permeate the 1.5m square and 15 cm thick field test section of compacted clay, broke through many of the replications within two weeks. The acetone waste took as long as two years to break through the test sections; however,r in the end, sections of each type of clay were also permeated by the acetone waste.

Field data and observations collected at active landfills and surface impoundments suggest that organic liquids have moved 10 to 1000 times faster than anticipated based on laboratory measurements made using water. Some of this increased mobility may be attributed to differences between laboratory and field conductivities, while the remainder is likely due to the impact of organic liquid on the properties of clay soils. There are now sufficient data available to provide a mechanistic explanation as to how organic liquids migrate rapidly through soils. These data suggest that organic liquids, which are only sparingly soluble in water or water soluble liquids in concentrations greater than about 50%, will desiccate clays causing them to shrink and crack.. The liquids are then able to flow through the newly formed macropores in the soil much more rapidly than when the soils are wetted with water.

Shackelford et al. (1988) studied Diffusion Of Inorganic Chemical Species In Compacted Clay Soil. This research was conducted to study the diffusion of inorganic chemicals in compacted clay soil for the design of waste containment barriers. The effective diffusion coefficients (D*) of anionic (Cl^-, Br^-, and I^-) and cationic (K, Cd^{2+}, and Zn^{2+}) species in a synthetic leachate were measured. Two clay soils were used in the study. The soils were compacted and pre-soaked to minimize mass transport due to suction in the soil. The results of the diffusion tests were analyzed using two analytical solutions to Fick's second law and a commercially available semi-analytical solution, POLLUTE 3.3. Mass balance calculations were performed to indicate possible sinks/sources in the diffusion system. Errors in mass balance were attributed to problems with the chemical analysis (I^-), the inefficiency of the extraction procedure (K^+) precipitation (Cd^{2+} and Zn^{2+}), and chemical complexation (Cl^- and Br^-). The D* values for Cl^- reported in this study are in excellent agreement with previous findings for other types of soil. The D values for the metals (K^+, Cd^{2+}, and Zn^{2+}) are thought to be high (conservative) due to: (1) Ca^{2+} saturation of the exchange complex of the clays; (2) precipitation of Cd^{2+} and Zn^{2+}; and (3) nonlinear adsorption behavior. In general, high D* values and conservative designs of waste containment barriers will result if the procedures described in this study are used to determine D* and the adsorption behaviour of the solutes is similar to that described in this study.

Shackelford (1991) reported Diffusion in Saturated Soil (Background and results). Recent studies suggest that diffusion may be an important, if not dominant, mechanism of contaminant transport through waste containment barriers. This paper represents the first of two papers pertaining to the measurement of diffusion coefficients of inorganic chemicals diffusing unsaturated soil. In this paper, both steady-state and transient equations describing the diffusive transport of inorganic chemicals are presented. Several factors affecting diffusion coefficients are identified. A method for measuring diffusion coefficients for compacted clay soil is described. The definition for the diffusion coefficient for diffusion in soil (known as the effective diffusion coefficient, D*) is shown to vary widely. In general, variations in the definition of D* result from consideration of the different factors that influence diffusion of solutes in soil and the different ways of including the volumetric water content in the governing equations. As a result of the variation in the definition of D*, errors in interpretation and comparison of D* values can result if the appropriate definition for D* is not used.

The effective diffusion coefficients, D*, of three anions (Br^-, Cl^-, and I^-) and three cations (Cd^{2+}, K^+, and Zn^{2+}) diffusing in two compacted clay soils, kaolinite and Lufkin clay, are measured. The ions are contained in a simulated waste leachate. The effects of molding water content and method of compaction on the measured D* values are evaluated for kaolinite. The calculated D* values varied between 4×10^{-10} m^2/s and 2×10^{-9} m^2/s and, based on the results for chloride diffusion in kaolinite, are relatively insensitive to molding water content and compaction method. The measured D* values for Cl^- and Br^- in kaolinite are in excellent agreement with previous studies, but the D* vakyes for the cations are relatively high. High D* values for the cations are attributed to nonlinear adsorption behaviour at relatively high concentrations and to the possibility of chemical precipitation of the heavy metal species (Cd^{2+} and Zn^{2+}). Also, D* values determined from reservoir concentrations typically are higher than D* values determined from soil concentration profiles.

Shackelford (1989) also reviewed Laboratory diffusion testing for waste disposal. A summary of effective diffusion coefficients from the literature suggests that the major physical factor affecting the value of the measured diffusion coefficient is the degree of saturation of the soil, with D*-values for nonreactive and reactive solutes in saturated soils being as much as 10-20 times higher than the corresponding values in unsaturated soils. Most of the other physical factors only become important in soils which are highly unsaturated. In addition, the diffusive transport rates of reactive solutes subject to reversible sorption reactions can be as much as 5000 times lower than those of nonreactive solutes in saturated soils and from 20 to 630,000 times lower in unsaturated soils.

Hills etal (1989) derived Model on One-Dimensional Infiltration Into Very Dry Soils (Model Development and Evaluation) and estimation of the soil water parameters and model predictions. With the increasing economic growth in the arid regions of the West, and with the growing need for waste disposal and storage, the ability to efficiently model water flow and pollutant transport through unsaturated soils is becoming more important. One of the more difficult water flow problems to model from a numerical point of view, is infiltration into very dry soils. The presence of very steep pressure gradients combined with the large field scales leads to algorithms that are very CPU intensive. Here we develop a water content based algorithm that is suitable for modeling one-dimensional unsaturated water flow into layered soils. We show that this algorithm is a numerical approximation of a general form of Richards equation. We compare the computational efficiency of this algorithm with that of two pressure ahead based finite difference water flow algorithms for several test problems. We find that the mass balance errors for the noniterative water content formulation are of the order of machine round off error for most applications. We also find that for soils with fairly wet initial conditions (h = -100 cm H_2O) the water content formulation requires approximately the same CPU time as the faster of the two pressure head formulations. For very dry soils (h = -1000 to -=50,000 cm H_2O) the CPU time required for the water content formulation is not a function of the initial water content of the soil, whereas the CPU time required for the pressure ahead formulation strongly increases with decreasing initial water content. Because of this lack of sensitivity to

initial conditions, the water content based algorithm is from 1 to 3 orders of magnitude faster than the pressure ahead based algorithms when applied to infiltration into very dry soils. The water content algorithm is not suitable for combined saturated-unsaturated or near-saturated flow that may be present because of local heterogeneities in the soil. In addition, the water content algorithm cannot handle positive pressure upper boundary conditions such as those associated with ponded surface water.

Using a water content based one-dimensional finite difference algorithm, we model infiltration into a 6-m-lusimeter column containing alternating layers of air dried clay loam and sand. We use van Genuchten's equation to model the h-θ relationship and both Campbell's and Mualem's equations to model the K-θ relationship. Several sets of model parameters are estimated using data generated from various combinations of laboratory drainage experiments, laboratory measurements of saturated hydraulic conductivity, lysimeter observations of initial conditions, and lysimeter observations of water redistribution. We find that predictions of infiltration based on field redistribution data give the best agreement with the observed infiltration into the lysimeter. We also find that the use of Campbell's K-θ relationship results in closer agreement between the infiltration model predictions and the lysimeter observations than does the use of Mualem's K-θ equation. The results of this study show that infiltration model predictions for a carefully controlled field scale lysimeter are very sensitive to the field and laboratory techniques used to estimate the soil

water parameters.

Harris and Urie studied Water Quality Effects and Growth Benefits of Entrenching SewageSludge in Sandy Forest Soils. Sewage sludge with 10-percent dry solids was entrenched at loading rates of 75 and 150 t/ha to measure its effects on water quality. Also, sludge cylinders 60 cm in diameter and 100 cm in depth with 10-, 15-, 20-, and 40-percent dry solids were buried in a hybrid poplar nursery to measure rooting and other growth effects. Lateral leaching was minimal, and leaching from the bottom of the trench had minimal effect on groundwater quality because of dilution. In the nursery, concentrations of soluble constituents were directly related to dry solids content. Sludge constituents stayed bound tightly except for the soluble portion. pH increased in the soil. Growth response of hybrid polars was directly related to availability of sludge nutrients. The high sludge loading rate results in nitrate pollution of any underlying water table aquifers but surrounding natural ecosystems should be able to denitrify and/or to assimilate the additional nitrogen.

Harris and Urie also reported heavy metal storage in soils of an aspen fertilized with municipal sludge. Municipal sewage was surface applied to aspen (populus grandidentata) on a simulated clear-cut, a siz-year-old sapling stand, and a standard operational clearcut. The soil was a Montcalm loamy sand (Alfic Haplorthod) with low fertility and water holding capacity. Single applications of sludge were applied at the rate of 11.5, 23, and 46 Mg/ha in the spring of 1976, 1977, and 1978. Some plots received a second application at the 11.5 and 23 Mg/ha rate the year following initial application. The aspen humus layer effectively immobilised a high proportion of the metals present in the sludge. Over a five-year period, most metal movement seemed to be limited to the upper 5 cm soil layer. The vegetation recycled heavy metals back to the humus layer. Repeated applications in the following year appear to increase leaching to the soil. Pre-treatment history of the aspen determines to some extent the overall immobilisation of the heavy metals. More metals were lost from humus layers that had been recently disturbed after years of accumulation. Humus on plots receiving heavier dosage rates of sludge seemed more efficient in the storage of heavy metals. The mineral soil system does not, over a three to five year period, appear to play a major part in heavy metal storage or movement at the treatment rates used.

Harris etal (1984) studied Sludge Fertilization Of Pine and Aspen Forests On Sand Soils In Michigan. Municipal and industrial sludge were applied to red pine and municipal sludge was applied to several other tree species and clearcut areas on sand soils (typic Haplorthods and spodic Udipsamments) to determine their renovation capacities and the feasibility of using sludge for forest fertilisation. Raw papermill wastewater sludge, 5.5. percent solids, was applied on red pine at rates between 5 and 40 $Mg.ha^{-1}$. Municipal sludge, 3 to 8 percent solids, was applied to aspen sprout stands, established white and red pine plantations, and clearcut jack pine sites at rates between 4.8 and 46 $Mg.ha^{-1}$. Biomass increase of both aspen sprouts and ground vegetation was related to sludge dosage. For all sludge treatments on aspen, biomass increased on an average of 78 percent over controls in the first growing season. In white and red pine plantations, growth responses occurred in the ground vegetation and in the size and weight of pine foliage, but not in bole size at dbh. Sludge treatment increased naturally occurring understory vegetation 200 to 500 percent in all tests. Foliage nitrogen increased in both trees and understory vegetation. Phosphorus concentrations increased in herbaceous species and pine foliage. Increased trace metal concentrations were found mostly in ground vegetation. The humus layer immobilised and stored most nutrients and trace metals either directly or after recycling through vegetation. Where humus was present, soil depths below 5 cm did not increase in measurable amounts of nutrients and metals. Where humus was not present, the organic matter in the soil immobilised sludge constituents. Nitrate-N in the soil water and groundwater was the

limiting factor for sludge loading rate. Sludge additions resulted in nutrient enrichment of the soils and increased production of the forest ecosystems. On the soils studied, 5-15 Mg.ha-1 of sludge were applied without leachates or groundwater exceeding the nitrate standards of drinking water.

Harris and Urie (1982) investigated changes in a Sandy Forest Soil Under Northern Hardwoods after 5 years of Sewage Effluent Irrigation. Thinned and unthinned plots in a 50-year-old beech (Fagus sp.)-maple (Acer sp.) stand in northwestern lower Michigan were irrigated with sewage lagoon effluent. After 5 years of effluent application at rates of 38 and 75 mm/week, litter weights were reduced, leaching was increased, and forest floor humus weights were increased. Irrigation also resulted in decreased organic matter in the mineral soil. Nitrogen and P were leached from the litter; Ca, Mg, and Na were retained in forest floor humus and mineral soil, greatly increasing the pH and base saturation. Nitrogen concentrations measured in leachate from the 120-cm soil depth were consistently below 10 mg. L-1. Sodium was the predominant cation in the leachate. Irrigation over 5 years with wastewater effluent has had such minimal effects that higher irrigation rates must be considered without posing serious environmental risks.

Harris Physical and Chemical Changes in Forested Michigan Sand soils Fertilized with Effluent and Sludge. Sludge applied to forested sand soils can improve the fertility of the soil. If the sludge is not directly plowed or disked into the soil, decomposition and incorporation into the system is much slower. Vegetation responses on surface-applied sludge plots indicate that many of the nutrients are used near or at the top of the soil surface. Before additional sludge applications are made, however, the sludge decomposition products should be accounted for. Threshold limits for sludge application rates in forested sand soil have yet to be determined.

Harris (1976) Sewage Effluent Infiltrates Frozen Forest Soil. Secondarily treated sewage effluent, applied at the rate of and 2 inches per week, infiltrated a frozen Sparta sand soil ɔrested with jack pine and scrub oak. Maximum frost depth in treated plots averaged 60 cm and in check plots averaged 35 cm. Nitrogen was mobile with some accumulation. Phosphorus was absorbed.

Harris (1972) Infiltration Rate as Affected by Soil Freezing Under Three Cover Types. Infiltration rate in a frozen Fayette silt loam soil under contiguous areas of natural deciduous forest, 25 year old coniferous plantation, and 6 year old abandoned field vegetation was measured over the winter of 1969-70 using tin can infiltrometers and a water-ethylene glycol solution. The deciduous forest site had a natural soil profile; the conifer plantation and abandoned field sites were once cultivated. Prefreeze infiltration rate was similar for all cover conditions. In deciduous forest and abandoned field plots, soil freezing did not change the infiltration rate sharply until late winter when infiltrating snowmelt and rainfall froze and closed soil pores. In the conifer plantation, the infiltration rate was nearly zero in early winter due to an impermeable snow-ice layer on the ground caused by snowmelt dripping from the conifer canopy. Because of large macropores, infiltration rates were high on the deciduous forest and abandoned field plots even when the frozen soil contained nearly 50% water by volume. Conifer plantations may thus contribute more surface run-off than deciduous forest or abandoned fields during snowmelt and winter rains.

Urie etal. Forest Land Treatment of Sewage Wastewater and Sludge in the Lake States. Lagoon-treated wastewater and secondary municipal and raw papermill sludge were applied to several tree species, both hardwood and softweed, on nutrient-poor sandy soils. Lagoon wastewater is low in nutrients with a range of total nitrogen between 2.5 and 15 per cent. Up to 90 per cent of the nitrogen was removed by young, growing forest. Survival and height growth increased in irrigated Christmas trees. Populus tripled in height and other species more than doubled. Sludge-treated forests responded equally well. Biomass increased in both aspen sprouts and the ground vegetation and was related to sludge dosage. Foliar nitrogen increased in all vegetation. Phosphorus increased in herbaceous species and pine foliage. Increased metal concentrations were found mostly in surface contaminated understory vegetation. The surface humus layer immobilised and stored most nutrients and trace metals either directly or after recycling through vegetation. On the soils studied, 5-15 t/ha of sludge were applied without leachates or groundwater exceeding the nitrate standards of drinking water.

Rutledge etal. On-site and clustered wastewater renovation by soil treatment overview. Soil treatment using on-site and clustered systems generally utilise a septic tank system which consists of (1) a septic tank, (2) a distribution system, and (3) the soil. Soil evaluation for on-site wastewater renovation consists of assessing the soil's ability to renovate and transmit wastewater. Numerous soil evaluation systems are presently used. Most approaches utilise (1) soil morphology or (2) percolation tests or (3) a combination of the two. Most workers recognise the superiority of a soil morphological approach which is increasing in use. A good evaluation should discriminate among numerous designs and lead to the most appropriate design. Improved distribution systems can enhance treatment by (1) spreading the effluent over the entire bed to reduce the loading rate, (2) introducing the effluent higher in the soil to increase the amount of soil available for treatment, and (3) introducing the effluent in smaller doses to increase the residence time in the soil.

Reneau etal (1987). Fate and Transport of Biological and Inorganic Contaminants from On-site Disposal of Domestic Wastewater. An on-site wastewater disposal system (OSWDS) is the primary method for domestic waste disposal in sparsely populated areas and innumerous suburban countries. The most common OSWDS is a septic tank with a subsurface soil absorption system that relies on gravity to move wastewater from the residence to the soil with minimal pretreatement of waste before application to the soil. Much of the renovation occurs as the wastewater percolates through the soil prior to reaching ground or surface waters. In 1980, 20.9 million residences (24.1% of the total in the USA) applied approximately 14 x 109 L of domestic wastewater to US soils each day. These numbers emphasise the need for assessing the effect of OSWDS on the quality of the environment. This review addresses the potential impact of selected biological and chemical contaminants present in domestic wastewater on environmental quality. Inefficient use of a soil s renovative capacity (primarily because of poor effluent distribution) can result in extensive travel distances for biological or chemical contaminants as well as hydraulic failure of the OSWDS. The need for further investigation of the potential for water contamination from nitrogenous components and possible mechanisms to reduce the degradation potential of N is addressed. Most studies assume that the dynamics of viral translocation through soil resemble those of fecal bacteria. This assumption may not be correct. Lastly, a critical examination of fate of N, viruses, and fecal bacteria introduced into soils via alternative OSWDS and modified conventional OSWDS should be a priority research initiative.

Reneau etal. Treatment by on-site systems. Optimisation of transmission and treatment of on-site wastewater disposal system (OSWDS) effluent through soil of soil material will become more important as increasing numbers of OSWDS are installed, particularly in marginally suited soils. Most OSWDS in the USA include a subsurface absorption system with perforated lines and gravity distribution. Research indicates that in both fine textured soils and permeable soils with shallow groundwaters, transmission and/or treatment are enhanced by use of shallow placed trenches or mounds and LPD. The improved effluent distribution allows primarily unsaturated flow below OSWDS. When flow is unsaturated, or travel distances through the soil are adequate, pathogen removal and die-off should be adequate. Likewise P removal was adequate in most OSWDS studied. Nitrogen remains the component with the greatest pollution potential due to leaching of NO_3 - and in some situations NH_{4+}. The potential for denitrification adjacent to OSWDS is still largely undetermined. However, the apparent large mounts of denitrification observed in several studies suggests the need for additional research in this area.

Sarker etal. Solubilities of p-Dichlorobenzene and Naphthalene in several Aqueous-Organic Solvent Mixtures. The effects of three alcohols, three ketones, pyridine, and ethyl acetate in enhancing the solubilities of p-dichlorobenzene and naphthalene in water are reported. Data were fitted to an equation of the form $S = S_o (1+KX_n)$, where solubility in aqueous-organic solvent solution, S_o = solubility in pure water, X = mole fraction organic solvent, and K and n are constant characteristic of the solute-organic solvent pair. Enhancement of solubilities of factors of nearly 90 were observed in some cases.

Godwin etal. (1986) Soil Injection of Liquid Wastes. The techniques for the disposal to agricultural land of either agricultural slurry or municipal sewage sludge are similar, and consist either of surface spreading or injecting the liquid waste below the soil surface. The soil injection technique has many advantages over surface spreading and the authors of this paper on a two year study to assess design and operational criteria for optimum performance.

Maynard etal. (1986) The effect of elemental sulfur on certain chemical and biological properties of surface organic horizons of a forest soil. Deposition of So has had a significant effect on the soil system close to the sulfur blocks. Elemental S has been oxidised to So42-S by the action of S-oxidising microorganisms, primarily T. thiooxidans. The oxidation of So has resulted in both direct chemical changes by lowering the pH and indirect changes through increased leaching of base cations and the solubilisation of Al and Fe. These chemical changes have, in turn, reduced the heterotrophic populations and the potential for C mineralisation. Plant responses to these chemical and biological changes have been dramatic and the understory vegetation has been virtually eliminated at the most contaminated site (Kennedy et al. 1985). Although the trees showed no outward response, the indirect effects of soil chemical and biological changes may only be detected with long-term studies.

Ghaly (1989). Biogas production from Acid Cheese Whey using Two-Stage Digester. A two-stage, no-mix anaerobic digester of 155 lt capacity was used to investigate the feasibility of biogas production and the pollution potential reduction of acid cheese whey. The digester was operated at a 15-day hydraulic retention time and three temperatures (19, 25, 35^{o}C). Both the temperature and pH of the whey had significant effects on the performance of the digester. The quantity and quality of biogas can be improved by controlling the pH of the outlet chamber where the methanogenic process takes place.

Ghaly and Singh (1988). Pollution Potential Reduction of Cheese Whey through Yeast Fermentation. Batch and continuous pilot-scale aerobic fermenters of 4.8 L operating volume were designed and constructed from plexiglas materials. The fermenters were used to study the kinetics of cheese whey fermentation using the yeast K. fragillis for pollution potential reduction and single cell protein production. Four retention times (6, 12, 18 and 24th) were used in this study. The fermentation process was successful in reducing the total chemical oxygen demand (COD) by 42%, the soluble COD by 65%, the total solids by 53%, and the ammonium nitrogen by 90%. There were also gains in the suspended solids and the organic nitrogen of 60 and 17% respectively. The reductions in the COD, total solids, and ammonium nitrogen, and the gains in the suspended solids and organic nitrogen were affected by the hydraulic retention time. More soluble material was converted to insoluble microbial cells at the 12-h hydraulic retention time, whereas greater pollution potential reduction was achieved at the 24-h hydraulic retention time for both batch and continuous operations.

Ghay etal. (1985) Land Disposal of Cheese Whey. A laboratory experiment was carried out to study the transformation and transport of nitrogenous compounds in soils receiving high application rate of cheese whey. The experimental apparatus consists of 36 soil columns constructed of PVC pipes with 20 cm inside diameter. Three types of soil (sandy loam, loam and sandy clay loam) and three soil depth (60, 120 and 180 cm) were studied. The average monthly rainfall for Halifax for the summer period was used. The results indicated that all soil types had high removal efficiency of the nitrogenous compounds. The concentration of nitrogenous compounds in the lechates decreased with the time. The nitrate concentration in the leachate was very high at the beginning of the experiment and therefore continuous application of cheese whey at higher rates may result in ground water contamination and becomes a threat to human and animal health.

Ghay etal. (1988) Potential Air and Groundwater Pollution from Land Disposal of Cheese Whey. Experiments were performed, using 280 cm (deep) soil columns with 20 cm inside diameter, to determine the relative amounts of nitrogen compounds leached from soils receiving high application rates of cheese whey from two seasons of application. Three soils (sandy loam, sand clay loam and loamy sand), three water table levels (100, 150 and 200 cm from the soil surface) and two cheese whey application rates (560 and 840 kg-N/ha) were used in the study. The leaching process was monitored over a period of 5 months each season. The observed concentrations of nitrogen compounds were low and little influenced by the cheese whey application rate and the ground water level. There were no significant losses of ammonia nitrogen through volatilisation.

Merkel etal. (1985) Municipal Sludge Fertilisation on Oak Forests in Michigan: Estimations of Long-term Growth Responses. Relationships between mean annual increment (MAI) and total nitrogen and phosphorus contents in forest floor and 0 to 45 cm soil samples were studied using regression methods. Twenty-nine forest sands were used with growths ranging from 1.19 to 4.26 m^3/ha per year. Nitrogen and phosphorus contents in the surface soil (A and E horizons), and nitrogen content in the fermentation and humus horizon (O2), accounted for nearly 70% of the variation in MAI. Nutrient contents in surface soil and O2 layers from control and sludge fertilised plots were inserted in the regression equation. A 29% increase in growth (MAI) was predicted based on two year sludge effects on forest floor and soil nutrient contents. A three year, 44% increase in basal area growth was found using conventional fertiliser trial techniques on the same area. Long term responses of this magnitude would require that soil nutrient changes persist or can be maintained through treatment. Use of site nutrient contents is a useful approach to the assessment of long term growth.

Nguyen etal. (1985) Municipal Sludge Fertilisation on Oak. Forests in Michigan: Short-term Nutrient Changes and Growth Responses. A research and demonstration project was initiated in 1981 in northern Michigan to explore the potential use of municipal waste on forest lands. Oak was one of four forest cover types studied. The forest stand was an upland mixed oak type with read oak (Quercus rubra L.) white oak (Q. alba L.) and red maple (Acer rubrum L.). Sludge was applied on three 1.5 ha plots at the rate of 8 Mg dry solids ha to provide 400 kg/ha of nitrogen from a liquid anaerobic source. Early results indicate the following responses: (1) There has been no tree mortality due to sludge application. (2) Tree growth over the control was observed for all species combined; cant increase of 63% in diameter growth over the control was observed for all species combined; basal area growth of all species combined exhibited a significant 44% increase over the control; a differential species response also occurred for diameter growth. (3) There were no effects on sapling diameter and basal area growth. (4) A large portion of the nonsoluble nutrients applied remained in the forest floor two years after application. (5) There were no differences in chemical properties of surface and subsurface soils two years after sludge application. (6) Nitrate-N concentration in soil leachate increased five months after treatment, but the peak concentration was less than 3 mg and decreased to background level within one year after sludge application.

Brockway and Nguyen. (1985) Municipal Sludge Application in Forests of Northern Michigan: A Cast Study. A large scale operational demonstration and research project was cooperatively established by the US Environmental Protection Agency, Michigan Department of Natural Resources, forest land application as option for sludge utilisation. Project objectives included completing (1) a logistic and economic assessment and demonstration of the technology available for conducting sludge applications in forest stands, and (2) several research studies that would augment knowledge in the potential toxicants, groundwater quality, nutrient cycling, and vegetation growth. Field trials in four forest types (aspen, oak, pine northern hardwoods) were of a completely random design covering 54 ha. of which 18 ha. were treated with nearly 4 million liters of anaerobically digested sludge. Average solids loading ranged from 8 to 10 Mg/ha. resulting in total nitrogen levels of 400 to 800 metals, and trace elements were generally not significant among treated plots. Sludge was transported by truck a distance of 80 km to the study sites and sprayed by an all-terrain tanker on the forest floor at a cost of $ 48,576. The resulting unit cost of 1.3 cents per litre was comparable to typical operational costs for sludge application to farmland, considering the greater transport distance in this study. Preliminary findings indicate an enhanced nutritive quality of forage on fertilised plots and a resulting increase in use by both deer and elk. Increases in plant growth were related to elevate levels of soil nitrogen, phosphorus, calcium and magnesium. Slight increases of nitrate-N were observed in soil percolate within one year of application, but

these rapidly returned to near background concentrations. Analysis of sociological data provided new insights into public concerns and attitudes and outlined a process for constructive citizen involvement in programme planning.

Hart etal. (1988) Silvicultural Use of Wastewater Sludge. In Michigan, sludge-applied nutrients substantially enhanced nutrient cycling, tree growth, wildlife habitat, and nutritional quality of forage plants in the forest. At appropriate application rates, these benefits were obtained while avoiding groundwater contamination and toxicant transmission in the food chain. Forestland application methods were shown to be technologically feasible and cost effective, providing the land manager with a valuable silvicultural option. Forestland application of wastewater sludge represents an important land management opportunity that also addresses an essential environmental need. We recommend that silvicultural use of wastewater sludge be considered by land managers to not only benefit tree growth and wildlife habitat but also highlight the participation of forestry professionals in publicly supported environmental protection programmes.

Moore etal. Wastewater Characteristics of A Flushing Dairy. The OSU Dairy Centre utilizes a flushing system to remove waste from their free-stall barn. After collection the flush water is passed over a stationary sloping screen and the solids stockpiled. The liquid fraction is stored in a 1,967 m^3 above ground holding tank. A floating aerator is installed in the storage tank for odor control. Monitoring the tank indicates the net rate of liquid waste accumulation to range from 15 to 35 m^3/day for the 150 head bran with higher values reflecting periods of sustained rainfall. With proper management attention, the liquid storage tank has sufficient capacity to allow wastewater application only when suitable soil conditions exist to permit application without a run-off hazard.

Baek etal. Modelling of Enhanced Biodegradation in Unsaturated Soil Zone. In an attempt to stimulate the mitigation of chemical contamination by microbial enrichment in existing unsaturated soil systems, two important characteristics, i.e. the influence of microorganisms on soil water flow and chemical removal rates, were incorporated into a mathematical model (BIOSOIL). Variable step and variable order Gear's Method was employed as a numerical approximation to solve the set of four differential equations. The resulting mathematical model described the behaviour of the biosoil system under varying input conditions. From this modelling study of chemical removal, the following conclusions were drawn: (1) The depth of the unsaturated soil ozone, a significant consideration in waste disposal practices, seems to be less crucial under bioremediation than generally thought; and (2) microbial distribution in a vertical column of soil is as important as the total population size of soil microorganisms. Study results suggests a guideline for the development of vertically well distributed biosoil systems; apply a limiting substrate at high concentration, at fast rates, and in infrequent cycles.

Johnson etal. (1989) Diffusive Contaminant Transport in Natural Clay: A Field Example and Implications for Clay-Lined Waste Disposal Sites. Vertical core samples were obtained from an impervious, unweathered, water saturated clay deposit beneath a 5 year old hazardous waste landfill at a site in southeastern Ontario. Sections of the cores were analyzed for chloride and volatile organic compounds. Waste derived chloride was detected in the clay to a maximum depth of 83 cm below the bottom of the landfill. The most mobile organic compounds were found only to a depth of 15 cm. The downward transport of these chemical species into the clay was the result of simple Fickian diffusion. This study has implications for low-permeability clay liners used at waste disposal sites. For liners of typical thickness (1m), simple diffusion can cause breakthrough of mobile contaminants in approximately 5 years; the diffusive flux of contaminants out of such liners can be large.

Kaysseh and Schenck. (1989) Reclamation of Saline Soils Using Calcium Sulfate Residues from the Titanium Industry. An attempt at desalination has been performed on two kinds of soils containing different levels of sodium chloride contamination. The study was carried out in upper-Alsace, France from 1980 to 1982. Contamination was caused by sylvinite extraction and by the potash industry. The two alluvial soils that were analysed contained sodium concentrates of 42 and 418 meq kg-1. The threshold limit level for plant growth is 30 meq. ha-1. Plaster and titanium-industry residues with high $CaSO_4$ contents were used as reclamation agents. Effects were compared to those obtained with natural precipitation and flood water. The results of the study suggest that the use of industrial residue as well as plaster is efficient for reclamation of fairly saline soils.

Mirsatari etal. (1987) Anaerobic Microbial Dechlorination: An Approach to On-site Treatment of Toxaphene-Contaminated Soil. Enhanced microbial degradation of toxaphene by natural microorganisms occurred in soil and sediment amended with organic matter kept under anaerobic (flooded) conditions. Laboratory experiments yielded a dissipation half-life of approximately 3 and 1 week for soil and sediment, respectively containing 10 ppm of technical toxaphene and a 1% alfalfa meal amendment. Dissipation was accompanied by an increase in early eluting gas chromatographic peaks and a decrease in later eluting peaks, indicating that dechlorination had occurred. Enhanced anaerobic dissipation also took place in soil containing 500 ppm of toxaphene, although at a lesser rate than at 10 ppm, and when cotton gin waste was used as amendment in place of alfalfa meal. Sediment in a toxaphene-contaminated pesticide waste disposal ditch was amended with 10% steer manure and flooded to ascertain field utility of the technique for on-site decontamination. Toxaphene residues were reduced from 63 to 23 ppm in 120 days, and some degradation activity still occurred up to 8 months after this single treatment.

Sawhney. (1989) Movement of Organic Chemicals through Landfill and Hazardous Waste Disposal Sites. Possible contamination of groundwater with organic chemicals from landfill and industrial waste dumps sites is of major public concern. Out of about 250 constituents of the USEPA's target compound list (TCL), 126 are organic chemicals - 35 volatiles, 65 semi-volatiles, and 26 pesticides and PCBs. Analyses of leachates from a number of landfills have revealed the presence of both volatile and semi-volatile organics. Similarly, soil, water and container samples from hazardous waste dump sites have been found to contain many of the TCL organic chemicals. Some sites contain large concentrations of these chemicals. Movement of organic chemicals is governed not only by the capacity of the soil to retain the chemical, but also by the soil environment, non-equilibrium interactions, and hydrogeology of the site. Effects of the soil environment and the non-equilibrium interactions on movement of organic chemicals are illustrated by reactions of phenol under aerobic and anaerobic conditions and persistence of volatile hydrocarbon 1,2-dichloropropane, respectively. Movement of organic chemicals in relation to hydrogeological features is illustrated from examples of groundwater analysis near landfill and chemical waste-disposal sites. Occurrences and concentration of TCL organic chemicals collected under USEPA's contract laboratory programme from suspected hazardous waste sites are described. The data are extremely useful in evaluating specific site contamination and environmental impact. However, determinations of possible groundwater contamination from the sites require groundwater monitoring and hydrogeological

investigations in accordance with the developed guidelines. Further analyses of the data in regard to concentrations of the chemicals in water and soil-sediment samples are necessary for investigations of likely relationships between their distribution and characteristics such as aqueous solubilities and partition coefficients.

Koch etal. (1989) Microbial Participation in Iodide Removal from Solution by Organic Soils. The migration of the long-lived nuclide 1291 in the bioshpere may be changed if the nuclide passes through an organic soil (organic soil soften occur in topographical depressions were groundwater generally enters the biosphere). The reactivity of I and, hence, its transportability may be altered in organic soil by processes in which microorganisms participate. The aim of this study, therefore, was to test for microbial participation in these processes. Twelve samples of nine organic soils, varying widely in degree of humification and in parent vegetation, were used in this study and were collected mainly on the Precambrian Shield of Ontario. Experiments were conducted using glucose, thymol, and radiation ($60C^{o}$) to stimulate or suppress microbial activity in the soils. The presence of glucose generally increased I-removal from solution whereas thymol depressed removal. Gamma irradiation of the soils decreased I- removal from solution in all samples, but 100 KGy terminated I- removal in only one sample. If the removal of I- from solution after exposing the soils to 100 KGy of radiation is termed nonbiological, the biological removal of I- from solution exceeded the non-biological in all samples but one. The natural I content of the soils was directly related to both the biologically and the non-biologically mediated processes of I- removal from solution We conclude that microorganisms play an important role in the processes of I- removal from solution in organic soils of the Precambrian Shield of Ontario.

Koch and Kay. (1987) Transportability of Iodide in some Organic Soil Materials from the Precambrian Shield of Ontario. Knowledge of the transportability of the long-lived and potentially hazardous nuclide 1291 in organic soil is important for evaluating the concept of safely disposing of radioactive fuel waste from Canadian nuclear power plants. The current concept for the disposal of nuclear fuel waste in Canada involves its emplacement in a vault mined 500-1000m deep in a stable plutonic rock formation in the Canadian Shield. Degradation over time of components of the vault could lead to the entry of 1291 to organic soils from contaminated groundwater. Twelve samples from nine organic soils, widely different in degree of humification and in parent vegetation, were collected from the Precambrian Shield of Ontario. Batch reaction techniques were used to measure the kinetics of iodide loss from solution in the presence of the organic soil materials. All soil materials exhibited an initial constant rate of iodide loss from solution (zero-order kinetics). The rate constants for iodide loss for the different soil materials ranged from 1.44 to 36.0 mg iodide per kilogram soil per day. The natural I content for the organic soil samples was positively correlated to the measured rate constant. It is concluded that the rate constant for iodide, as measured in the laboratory, is related to the processes that operate in the field to immobilize I under natural conditions, and that a zero-order kinetic model is appropriate for describing the loss of iodide from the solution phase in an organic soil.

Davol etal. (1988) Mutagenic Potential of Runoff Water from Soils amended with three Hazardous Industrial Wastes. The bacterial mutagenicity of runoff water from soils contaminated with hazardous industrial waste was monitored for a three year period using Salmonella thphimurium strain TA98 with and without metabolic activation. The wastes included a wood-preserving waste, a combined American Petroleum Institute (API) separator/slop oil emulsion sludge and a storm-water runoff impoundment waste. The waste were applied to a Weswood silt loam soil (Fluventic Ustochrept) and a Bastrop clay loam soil (Udic Paleustalf) at a rate of 3.1% (wt./wt.) for the wood-preserving waste and of 4.5% for the two refinery wastes. The results indicate that the runoff water from each of the waste-amended soils contained mutagenic constituents. The maximum specific activity was 783 net revertants per milligram residue, which was induced by the runoff water collected from the storm-water runoff impounded Weswood soil 360 d after application and assayed with metabolic activation. The sample also yielded the maximum weighted activity of 6,554 revertants per liter of runoff water. The mutagenic activities of the runoff water from all waste-amended soils displayed significant increases through 360 d after application, and in most cases, significant decreases in the samples collected approximately three years after application. The mutagenic activities of the runoff water from the Weswood soil were consistently greater than the activities of the runoff water from the Bastrop soil. These results indicate that three years or more may be required for the mutagenic activity of runoff water to return to background level, and that different soils will differ

in their capacities to retain mutagent chemicals during rainfall events.

Barbur and Young etal. Vegetative Filter Treatment of Dairy Wastewater and Lot Runoff in Southern Appalachia. Vegetative filters represent a lower-cost, lower-management wastewater treatment technology than conventional retention pond-irrigation systems and are much more likely to be implemented by small to moderately-sized dairymen. Properly planned vegetative filters on soils having moderate to high infiltration/permeability rates are an alternative wastewater treatment technology that can be compatible with areawide water quality goals. Vegetative filters can be successful on slopes to 10% by dividing the filter length into 4-5 segments using parallel contoured terraces. Excessive hydraulic loadings severely hamper the effective treatment capability of a vegetative filter. Water conservation and lot runoff reduction should receive top priority. Manure solids should be removed from the settling basin every 60 days or after each major rainfall runoff event. Uniform wastewater distribution across the filter width is extremely important but more development needs to be done on low cost, easily maintained distribution systems. The most successful filter performance results from alternately dosing and resting individual segments. Filter runoff organic and nutrient concentrations can be highly influenced by wastewater residence time on the filter surface and filter flow length.

Lisk, 1991. Environmental Effects of Landfills. In the past, landfilling involved burying municipal refuse directly or after on-site burning. Typically, little attention was given to proper siting and engineering to obviate the hazards of the generation of CH_4 and toxic leachates as wastes decomposed. Leachates were hopefully attenuated by natural processes (adsorption, precipitation, ion exchange, microbial decomposition or dilution in the unsaturated zone below landfills). Landfills slowly evolved by proper siting, design and management into efficiently operated bioreactors to produce purified CH_4 for use as a fuel, and leachates, which were treated biologically and chemically to minimize groundwater pollution. Microbial reactions in landfills are outlined. The amounts and compostiion of landfill gas and leachate as determined by the interaction of factors such as refuse compsition, degree of compaction, temperature, moisture content, refuse age and depth are discussed. Typical inorganic and organic composition of landfill gases and leachates are presented. The potential and real environmental effects on soils, plants, groundwater, aquatic organisms and humans of disposal of municipal refuse by landfilling are reviewed. Finally, the most recent trend in constructing refuse landfills to serve as final storage reservoirs which are deliberately kept dry to minimize gas and leachate production is discussed and illustrated. Present activities in waste recycling to conserve landfill space are outlined.

Jurgens, Rath R. and Schlesing H. Case Study and Proposed Decontamination of a closed Herbicide Plant Site. During the investigation as in one area high concentrations of 2, 3, 7, 8-TCDD were detected in the soil, an immediate response action began. The surface was excavated down to 0.5 meters and in the surrounding of one boring the area, which was determined in consultation with the environmental agency, the soil was excavated down to a depth of 4 meters. All the excavated soil was filled into bigbags. Dekonta had to build an interim store in which all the excavated soil (about 2600 m^3) is stored until to its decontamination. For this storage a permission by the agency was needed. Since hte beginning of 1986 organic material, mostly chlorobenzenes, were pumped out of the bottom of two wells. Until April 1988 we will have removed approximately more than 7 tons of that material from the influence of the groundwater. The excavation of deeper layers down to the impervious clay is not mandatory necessary, but possibly recommended in order to protect the groundwater. According to Tabasaran it is impossible to set up target levels for the clean up of the site. He prefers a site specific solution of the problem in the way described. This proposal was in December 1987 still under discussion with the appropriate Hamburg authorities.

Barth and Kroes (1985). Livestock Waste Lagoon Sludge Characterization. An effective probe was demonstrated for measuring sludge and total depth in livestock waste lagoons. An effective supernatant and sludge was developed and demonstrated for lagoons up to 3.0 m deep. Physical and chemical characteristics of the sludge and supernatant are presented. Sludge accumulation rates for mature livestock waste lagoons subject to moderate loading rates, expressed as m^3/kg TS added to the lagoon were:

Poultry - layer 0.00184 Swine - 0.00303 Dairy - 0.00455
pullet 0.00284

Long term VS degradation in waste lagoons expressed as a percentage of the estimated load were found to be:

Poultry - layer - 79 Swine - 81 Dairy - 55
pullet - 80

A conceptual model of sludge accumulation in a livestock waste lagoon is presented. Explanation of inert sludge accumulation in lagoons must account for the deposition of a large fraction of FS (sometimes more than 50% of the total sludge solids) and the nonbiodegrabale VS. Data collected from measurements of long term accumulations of inert sludge in animal and poultry lagoons are now the best estimates for designing lagoons for waste treatment and sludge storage. Maximum inert sludge accumulation in livestock waste lagoons should be limited to 60% of the operating volume of moderately loaded lagoons to insure continuing efficient operation. A significant added FS load on the dairy lagoon, as much as 100% of the manure FS load, results from soil carried to the cowyard on bodies of dairy animals having access to pastures and paddocks and from free stall litter and base materials.

Krause R. 1987. Controlled Land Application of Liquid Manure and Sewage Sludge with Tankers. Rational utilization of natural resources and the necessity of environmental protection require improved application techniques for organic sludges. Pretreatment and upgrading can improve handling as well as the fertilizing effect. With adequate tankers and implements negative effects on the soil and plant can be minimized. A new approach using adequate sensors and electric, electronic and hydraulic components was suggested for improving the dosage as well as longitudinal and transversal distribution of sludges. The complete system was developed and investigated in laboratory and field experiments. By direct, shallow incorporation of sludges not only were the yield increased and the physical properties of the soil improved, but pollution was reduced.

Korcak R.F. 1985. Effect of coal combustion wastes used as lime substitutes in nutrition of apples in three soils. Fluidized bed combustion represents a feasible technology for energy production utilizing high S fossil fuels. The process generates not only bed waste (FBW) (coal ash plus $CaSO_4$ and unreacted CaO) but also flyash (FA). The later waste has not been evaluated for its effects on plants and soils. A greeenhouse experimetn, using apple seedlings, was carried out using FBM, FA anc calcitic limestone applied at or up to twice the lime requirement on three soil materials. Seedling growth varied dependent upon the treatment-soil combination. Growth was reduced by 60% on the Manor soil from FA applied at twice the lime requirement and was attributed to the higher initial reactiveness of the FA comparec to FBM or limestone. Leaf P, K, N, Cu and Al were not significantly affected by treatments over all soils while Ca and N decreased and Mg varied dependent upon treatment. Soil pH was increased by all treatments. DTPA (diethylenetriaminepentaacetic acid) extractable Mn and Zn were good estimators of leaf Mn and Zn while DTPA Cu and Fe were not.

Korcak R.F. 1988. Fluidized bed Material applied at Disposal levels: Effects on an Apple Orchard. Atmospheric fluidized-bed combustion represents an economical technology for the burning of high S fossil fuel. The combustion resiude is a dry, alkaline material resulting from the burning of coal (or other fuel source) and limestone. Although the residue has been assessed as a lime-stone substitute, the current study examines the ptential for disposing of relatively large quantities. Fluidized bed material (FBM) was applied at two rates to the surface area within the rows of an established appled (Malus domestica Borkh.) orchard containing four tree types. The rates were either 9.2 kg/m^2 (low rate), 36 kg/m^2 (high rate) or untreated control. The tree types used were 'Spuree Rome' on M9, 'Redchief Delicious on M9 or M9/MM106, and 'Sturdeespur Delicious' pmM9. Cumulative yields (kg/tree) were enhanced on three or four tree types over a period of 6yr. A 15% reduction in yield was noted for Redchief Delicious on M9/MM106 stocks at the high FBM rate. No nutritional related problems were noted for this or any other of the tree type used. Part of the yield reduction noted was due to fruit size differences and/or differential sensitivity of this interstock rootstock combination to the altered soil chemical properties. Generally, amended soil pH increased to about 7.0 for either rate. and electrical conductivity increased five fold at the high rate of FBM addition. Agricultural utilization of large volumes (up to 112 Mg/ha) of FBM, compared to past research where FBM was used as lime substitute (2-6mg/ha), appears to be a feasible alternative. However, rootstock selection for apple may need to consider the resultant changes in soil chemical status form FBM additions.

Mote, and Griffis. On-site domestic wasteater renovation system designs to overcome soil limitations. There are basically two characteristics that limit the utility of soils for conventionally designed filter fields:

1. Insufficient depth, and
2. Unsatisfactory hydraulic conductivity

Two design approaches available for overcoming depth limitations are locating seepage trenches higher in the soil, and lowering water tables in soils where depth limitations result from goundwater occurring at shallow depths. Proper distribution is also important for overcoming depth limitations, and it is the primary means available for providing properly functioning systems in soils with hydraulic conductivity limitations.

Chawla and Viswanathan. 1989. Role of Predictive Ecotoxicology and Biological Monitoring in the Management of Aquatic Ecosystems. The role of biological monitoring and ecotoxicology in the identification of problems faced by aquatic ecosystems due to pollution and its prediction and prevention is clear. However, this science is still in it's infancy in India in terms of capabilities, facilities and human resources and needs considerable advancement. Apart from toxic chemicals in agricultural, industrial effluents and domestic sewage, pathogens and other human and environmental risk factors in aquatic ecosystems, also have to be considered during environmental impact assessment and management. While developing standard tests and regulatory guidelines alongwith safety of humans, animal husbandry and crops, ecosystem productivity and natural equilibrium also have to be taken as the end points. Endangered species have to be identified and proteted. Evaluation of safety of effluents including use of recycled water for irrigation and the consumer acceptability of food item raised thereby, will go a long way in making the wasteful nuisance of polluted water as a resource. This is all the more important in situations of draught. Effluent safety standards reched by proper management of water resoures would minimize any human risks caused due to utilizing recycled or polluted waters. Thus biological monitoring and aquatic toxicology have to be developed in India to achieve proper management of aquatic ecosystems and water resources.

Joshi and Dutta 1987. Studies on Lignin Removal by Soil perfusion Technique. Studies were carried out using a soil perfusion apparatus for the removal of lignin from waste water. It was observed that when a medium (ph 7.0) with lignin having about 1200 color units was perused through a soil column, perfusate contained only 250 to 300 color units after three days fo perfusion and pH was reduced to less than 5.0 with 70 to 80% reduction in Total Organic Carbon (TOC). With a sterile soil column the color was not removed and there was no change in TOC content. When the medium was buffered at pH 7.0, there was no reduction in color units. When the pH of the perusate reduced to less than 5.0, it was also observed that the nitrate content had increased considerably. These results indicated that due to microbial activity lignin molecules might have been biotransformed and adsorbed on the soil column at lower pH. The major group of microorganisms were also isolated from the soil and their significance is discussed in this paper.

Wolt. 1985. Utilizationo of Organic Wastes on Agricultural Soils of Tennessee. The data presented in this bulletin serve to indicate the value of diverse types of organic wastes as sources of N for crops. Furthermore, they provide an estimate of TKN loadings required to achieve maximum yields when organic wastes are applied to forage crops (corn silage, wheat and rye haylage. and bermudagrass) over relatively short periods of continued application (three years or less). Waste generators and crop producers wishing to land - apply organic wastes must be aware of the many factors that allow for waste disposal/utilization on croplan in an environmentally sound manner. Detailed information for planning for land application of organic waste can be found in Animal Wastes and Municipal and Industrial Wastes.

Kearney et al., 1984. A Large Scale UV-Ozonation Degradation Unit - Field Trials on Soil Pesticide Waste Disposal. Decomposition of farm-generated pesticide wastewater was demonstrated with a mobile 66-lamp ultraviolet (UV) unit and ozone. Aqueous solutions of 2,4-D (1086 ppm) and atrazine (4480 ppm) were degraded more than 80% in about 2-3 h, while paraquat (1500 ppm) was degraded more slowly. Dwell time, or the time the molecule was actually in the lamp unit, and concentration were two parameters that affected the rate of degradation. Mass spectra of the trimethylsily (TMS) derivatives of atrazine subjected to UV-ozonation revealed a number of dehalogenated, dealkylated s-triazines, paaquat yielded the 4-picolinic acid, and 2,4-D gave oxalic acid, glycolic acid and several four-carbon oxidation as a petreatment for land disposal compares favorably with incineration and other options open to the small pesticide user.

Somich et al. 1990. On-Site Treatment of Pesticide Waste and Rinsate Using Ozone and Biologically Active Soil. Pesticide waste and rinsate (PWR) obtained from a small farm was treated on site with ozone (18 h) and hten circulated through a biologically active soil column (48 h). Concentrations of atrazine (2-chloro--(ethylamino)-6-(isopropylamino)-s-triazinel), cyanazine (2-chloro-4-[(1-cyano-(1-methylethyl) aminol]-6-(ethylamino)-s-triazine], and metolachlor [2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl) acetamide] were decreased from 17, 30 and 82 ppm, respectively, to less than 5 ppm. The concentration of the other major pesticide component, paraquat (1,1'-dimethyl-4,4'-bipyridinium dichloride), decreased from 40 to 22 ppm. Laboratory studies showed that the rate of ozonation of these mixed pesticides was not first order as was observed in pur solutions. Ozonolysis yielded products that were uch more amenable to biological degradation than parent material. Bioassays of treated solutions indicated that herbicidal activity was eliminated. No evidence of mutagenic activity was indicated in Ames assays.

Hapeman-Somich. Mineralization of Pesticide Degradation Products. The chemical degradation products of four pesticides have been characterized and in a few cases were found to be similar to products observed in microbial processes. Ozonation reactions typically did not revolve chlorine removal. Rather ozone and other oxidants formed during the reaction cleaved double bonds, opened aromatic rings, removed or oxidized alkyl groups giving rise to alcohols, carbonyls or carboxylic acids. Similar oxidation products were obtained in photolytic reactions although dechlorination readily occured. In all cases, chemical pretreatment was found to enhance the rate of microbial mineralization, although the s-triazines were more slowly mineralized than paraquat or the chloroacetanilides, alachlor and metolachlr. It may be necessary, therefore to provide organisms capable of carrying out the desired transformations as opposed to relying on indigenous soil mircobes to mineralize these chemical degradation products. Development of methods to insure rapid mineralization of pesticides in aqueous matrices iwll reduce the threat of contamination to surface and groundwater supplies.

Lisk 1988. Environmental implications of incineration of Municipal Solid Waste and Ash Disposal. Owing to unsightliness and the threat of goundwater pollution, landfilling of municipal solid waste (MSW) is giving way to incineration in many communities. Environmental contamination from particulate and gaseous emissions containing heavy metals, polychlorinated dibenzodioxins (PCDD) and polychlorinated dibenzofurans (PCDF), polycyclic aromatics (PCA), acids and other compounds ;from such incinerators, as well as safe ash disposal, are of great concern. Concentration ranges of elements and organic toxicants in incinerators, ashes, emissions and cooling wasters are given. The literature is reviewed concerning the effects on incinerator operating parameters on emissions. incinerators equipped wiht modern pollution control devices (electrostatic precipitators, fabric filters, dry scrubbers, spray towers) and operated at optimum temperature with sufficient oxygen, turbulence (mixing) and residence time for complete combustion appear to minimize ash, elemental, gaseous and organic emissions. Environmental aspects of MSW incineration are considred and reviewed. The presence of metals and organics in incine of the effect of that soil on metal availability to plants. Thirty five milliliter volumes of separate solutions of Cd (0.18 mol m^{-3}), Co (0.34 mol M^{-3}), Cr (0.77 mol m^{-3}), Cu (1.10 mol m^{-3}), Ni (0.34 mol m^{-3}), Pb (0.97 mol m^{-3}), Sb (1.64 mol m^{-3}), and Zn (0.61 mol m^{-3}) were equilibrated for 6 d with 5-g samples of soil from the A horizons and some B horizons of 10 mineral and three organic soils (21 samples). Total removal from solution (sorption) was determined. The samples then were extracted with 1 M KCl so the quanitity of nonexchangeable metal could be determined. The respective ranges

of sorbed and nonexchangeable metal, expressed as a percentage of the total quantity of metal in the inital solution were: Cd 0-90, 0-55; Co 15-93, 1-89; Cr 31-100, 22-100; Cu 36-100, 13-100; Ni 12-95, 5-82; Pb 31-100, 14-98; Sb 50-100, 42-99; Zn 13-98, 5-94. Stepwise ;multiple regression was performed (on mineral soils only) using sand; silt; clay; pH; cation exchange capacity (CEC); exchangeable cations; organic matter; dithonite-extractable Al and Fe; and ammonium oxalate-extractable Al, Fe, and Mn as independent variables and the quantitiy of sorbed or nonexchangeable metal as the dependent ;variable. Sorbed and nonexchangeable Cd, Co, Cu, Ni and Zn were related mainly to soil pH or dithonite-extractable Fe (Fe_d). Sorbed and nonexchangeable Cr, Pb and Sb were related mainly to Fe_d, ammonium oxalate-extractable Fe, Sand or clay. RElative retention of metals by soil was in the order Ph > Sb > Cu > Cr > Zn > Ni > Co > Cd. Although CEC is widely used in regulation governing metal loading rates on agricultural land, the results of this study indicate that Fe oxides and clay content would be better parameters to use for soils of the southeastern USA.

Juwarkar and Subrahmanyam P.V.R. 1987. Impact of pulp and paper mill wastewater on crop and soil. Exhaustive field and laboatory studies were carried out for 3 years using pulp mill wastewater fro crop irrigation. Anaerobically treated pulp mill wastewater used in the study falls under hte class C_3S_1 to C_4S_2 and found suitable for use on coarse textured soils with salt tolarant crops. Crops like maize, barley, wheat, kenaf and sesbenis were grown successfully. Wastewater irrigation increases the soil exchangeable sodium per cent (ESP). The increase in ESP at hte end of 3rd year was 30.0. However even at this level there was no appreciable decrease in yield of crops and hydraulic properties of soil. Soil equilibrium studies showed that if the pulp mill wastewater is diluted with chlorination and hypochlorite wastewater in either 4:1 ro 3:1 proportions, the resulting wastewaer can be successfully used on coarse to medium textured soils without the problem of sodicity.

Chong C., Cline R.A. and Rinker D.L. 1988. Use of papermill Sludge in Container Crop Culture. Four types of papermill sludge added at 33% by volume to bark in containers were evaluated: primary; secondary; a mixture of primary and secondary from the Quebec and Ontario Paper Co.; and a mixture of primary and secondary from the Fraser Paper Co. *Spiraea* x *bumalda* grew best in amended secondarly sluge, which had the highest initial N content. In contrast, poorest growth occurred in Fraser mixture which had the lowest initial N content. Growth and also initial N content in other sludges were intermediate. Leaf nutrients did not reflect sludge treatments.

Chong C., Cline R.A. and Rinker D.L. 1987. Spent Mushroom compost and papermill sludge as soil amendments for containerized nursery crops. Two sources of mushroom compost were evaluated as soil amendments with bark: (1) unweathered (UMC) in proportions of 25, 50, 75 and 100% by volume, and (2) weathered (WMC) in proportions of 25, 50, and 75%. Three was also a 100% bark control treatment. Both red osier dogwood (Cornus stolonifera[syn. C. sericea]) and forsythia (Forsythia x intermedia Lynwood') grew well in all media. While plant height was little afected by the amount of mushroom compost in the media, top dry weight of the two species was increased in proportion to the amount of both UMC and WMC. Regardless of the media treatment, there was no apparent symptoms of nutrient toxicity or deficiency. Of four types of papermill sludge (primary, secondary, mixture of primary and secondary from Ontario Paper Co., and a mixture of primary and secondary from Fraser Paper Co. added at 33% by volume to bark, secondary sludge which has the highest N content provided the best growth of spiraea (Spiraea x bumelda); however, foliage of plants was dark blue-green in color reflecting high N. Unacceptably poor growth occurred in Fraser amended media because of low N.

Haeni H. and Gupta S. 1983. Choice of an extractant for simulating the availability and absorption of heavy metals by plants. Mild extractants like water or neutral salt solutions are best suited to simulate the plant availability of heavy metals in polluted soils. The importance of this result for testing the limiting values of heavy metals in soils is shown.

Gupta S., Blatter A. and Hani H. 1988. Concentration of Ionic Copper in Soil Solution. Total metal concentration either in salt extracts of soils or saturation extracts, probably allows the best estimate of the deleterious effects of metals on soil microorganisms and plants. In case of some metals like copper, the prediction of deleterious effect could be improved with the knowledge would also help in better understanding of competetive relationships of metal in contaminated soils and their consequences on soil microorganisms and plants grown on them.

Elsavage R.E. and Sexstone A.J. 1988. Biodegradation of a dilute waste oil emulsion applied to soil. The use of land treatment for disposal of a dilute waste oil emulsion generated by an aluminum rolling industry was investigated. Major components of the waste, identified by gas chromatography and mass spectrometry, were linear and branched (C_{12}-C_{25}) and fatty acid emulsifiers (primarily isomers of oleic acid). Hexadecane and pristane were readily biodegraded in vitro when added to soil collected from the waste disposal site. Hydrocarbons and fatty acids extracted from the waste were similarly biodegraded, however, the rate fo decompostiion may have depended on the history of waste applications to soil collected from the land treatment site. The apparent half-life of resolvable waste hydrocarbons and fatty acids was 9.5 days in soil which had received waste applications averaging 24.4 lm^{-2} wk^{-1}. In contrast, soil receiving either 50.8 lm^{-2} wk^{-1} or no waste applications during summer 1987 apparent exhibited half-lives of 28.1 and 60.3 days, respectively. Waste components were restricted to the upper 48 cm of the soil cores collected from the disposal site. Core samples also provided evidence for biodegradation of hydrocarbons and fatty acids, as well as an accumulation of other compounds not readily resolvable by gas chromatorgraphy.

Boyle M. and Paul E.A. 1989. Nitrogen transformations in Soils previously amended with Sewage Sludge. This short-term (10-d) incubation experiment established the rates of nitrogen (N) transformations occurring in sludge-amended and nonamended soil. Utilizing a nitrification block (C_2H_2) with $(^{15}NH_4)_2SO_4$, first-order rate constants were calculated for N immobilization, ammonification, nitrifiaction, and denitrification. These rate constants were compared to values obtained after a long-term (87-wk) incubation performed on sols sampled from the same fielc plots. The short-term rates of ammonification were still higher than the controls 4 yr after the last sludge addition. Sludge applications over an 8-yr period (180 Mg ha^{-1} yr^{-1}) reduced soil nitrification potential compared to the controls when spiked with ^{15}N. Denitrification did not cause a significant loss of N during either a short or long-term incubation period. The microbial biomass in the sludge-amended soil contained more N, which resulted in a microbial C/N ratio of approximately 4:1 vs. 5:1 for the controls. Initial (short-term) N immobilization rate constants were 0.43 for the sludge-amended and 0.35 for tre nonamended soil.

Table : 5.8 Composition of Antibiotic Fermentation Wastes
(Bewick, 1980)

	Tylosin	Oxytetracycline	Penicillin
Water (%)	83.6	65.7	80.8
pH	6	2.2	*
Organic matter (as % of dry weight)	85.5	50	90.8
Organic C (as % of dry weight)	43.7	26.5	40.7
N	6.34	2.80	5.92
P	2.00	0.43	1.36
K	0.59	0.07	0.38
Ca	0.30	0.71	0.72
Na	0.21	0.35	0.25
Microelements (ppm):			
Mg	500	60	550
Fe	275	460	60
Mn	7	11	6
Cu	245	3.5	5
Pb	15	5	5
Cd	1.5	1.5	1
Antibiotic content (ppm)	2000	1500	*

* - Figures not available.

Table : 5.9 Chemical Analysis of Compost
(Hughes, 1980)

Nitrogen	1.33%
P_2O_5	0.83%
K_2O	0.36%
Humus	53.70%
Calcium	5.61%
Iron	2.1%
Zinc	285 ppm
Lead	575 ppm
Copper	65 ppm
Cadmium	5 ppm
Iron	21,250 ppm
pH	7.2

Table : 5.10 Typical Analysis of Anaerobically andAerobically Digested Sewage Sludge Produced by Metropolitan Denver Sewage Disposal District No. 1. (Sabely 1980)

	Elemental Analysis			
	Anaerobically Digested Primary Sludge (Total Solids - 5.7%)		Anaerobically Digested Waste Activated Sludge (Total Solids - 4.4%)	
Element	Dry Weight Basis(%)	Wet(mg/1)	Dry Weight Basis(%)	Wet(mg/1)
N (Organic)	2.800	1,600.00	6.600	2,900.00
P	1.300	741.00	3.100	1,360.00
K	1.100	627.00	1.300	572.00
Ti	0.180	103.00	0.180	79.00
Cr	0.021	12.00	0.065	29.00
Mn	0.035	20.00	0.035	15.00
Fe	1.700	970.00	1.000	440.00
Co	0.001	0.60	0.001	0.44
Ni	0.024	14.00	0.025	11.00
Cu	0.130	74.00	0.230	101.00
Zn	0.400	228.00	0.480	211.00
Br	0.002	1.10	0.003	1.30
Rb	0.004	2.30	0.008	3.50
Sr	0.037	22.00	0.023	10.10
Y	0.010	5.70	0.004	1.80
Zr	0.041	23.00	0.014	6.20
Mo	0.006	3.40	0.001	0.44
Ag	0.007	4.00	0.011	4.80
Cd	0.003	1.70	0.009	4.00
Sn	0.020	11.00	0.016	7.00
Ba	0.170	97.00	0.084	37.00
Pb	0.170	97.00	0.093	41.00
U	0.002	1.10	-	-
As	-	-	0.002	0.89
Se	-	-	0.006	2.60

Table : 5.11 Average Chemical Composition of Pekilo Product (Smith, 1980)

	(g/16g N)
Threonine	4.8
Valine	5.0
Methionine	1.6
Isoleucine	4.6
Leucine	7.1
Tyrosine	4.0
Phenylalanine	4.2
Lysine	6.5
	(%)
Moisture, max.	6.0
Crude gat	1.3
Crude protein	55
Crude fiber	7
N-free extracts	25
Ash	6
Nucleic acids	10
	(ppm)
Thiamine	7
Riboflavin	70
Pyridoxin	20
Niacin	450
Pantothenic acid	60
Biotin	2
Folic acid	15

Source : Romantschuk and Lehtomaki. 1978.

Table : 5.12 Composition of By-Product Recovered from Slaugterhouse Effluent. (Grant, 1980)

Batch No.	1	2	3	4	5	6	Means
Nitrogen (%)	10.5	11.0	11.3	11.5	11.5	10.6	11.1
Protein (%)	65.5	68.0	70.5	72.0	72.0	65.5	68.9
Total Organics (%)	74.5	78.3	77.6	77.4	76.2	72.7	76.1
Ash (%)	21.8	17.7	18.5	19.1	20.0	23.6	20.1
Moisture (%)	3.7	4.0	3.9	3.5	3.8	3.7	3.8

Table : 5.13 **Amino Acid Composition of Recovered Solids from Meat Works Effluent (g amino acid/16 g nitrogen)**

Amino Acid	Recovered Solids Fraction A	Recovered Solids Fraction B	Reference Proteins Fibrin	Reference Proteins Hemo-globins	Reference Proteins Serum Proteins	Reference Proteins Casein
Lysine	8.8	8.5	9.1	9.1	10.0	8.5
Histidine	3.9	5.9	2.9	8.0	3.3	3.2
Arginine	4.4	4.7	7.8	3.9	5.8	4.2
Aspartic acid	14.3	9.4	11.9	9.8	10.3	7.0
Threonine	7.9	4.5	7.3	5.6	12.6	4.5
Serine	7.7	5.7	12.5	5.5	18.2	6.8
Glutamic acid	19.3	10.0	15.0	8.1	14.2	23.0
Proline	6.6	3.2	5.3	4.7	5.5	13.1
Glycine	5.5	3.5	5.4	5.3	2.0	2.1
Alanine	8.8	6.8	4.0	9.8	-	3.3
Cystine (half)	trace	trace	3.8	1.0-2.2	7.0	0.8
Valine	11.0	8.2	5.6	9.0	7.5	7.7
Methionine	2.8	3.2	2.6	1.0	4.0	3.5
Isoleucine	5.5	4.1	5.6	0.2	3.4	7.5
Leucine	17.1	15.0	7.1	14.4	10.1	10.0
Tyrosine	5.5	3.2	6.0	2.9	5.5	6.4
Phenylalanine	9.9	7.9	4.5	7.8	5.2	6.3

Table : 5.14 Chemical Composition of Tannery Sludges (% dry matter) (Mazur and Koe, 1980)

Element	Mean	Range
Total Nitrogen	3.78	1.97-5.67
Ammonium nitrogen	0.25	-
Phosphorus	0.25	0.09-0.49
Potassium	0.09	0.04-0.21
Calcium	3.83	1.00-7.51
Magnesium	0.27	0.01-0.94
Sulfur	2.86	1.22-5.45
Sodium	1.39	0.13-6.37
Iron	0.95	0.001-12.52
CHromium	1.29	0.34-2.80

Table : 5.15 Chemical Composition of Coffee Pulp. (Topps, 1980)

	Range (g/kg dry matter)
Crude protein (N x 6.25)	90.1-128.1
Ether extract	21-29
Crude fiber	146-240
Ash	64-96
Nitrogen-free extract	534-678
Calcium	6.34
Phosphorus	1.33
Magnesium	trace
Sodium	1.14
Potassium	20.2
Zinc	4.6 (mg/kg)
Copper	5.7 (mg/kg)
Manganese	7.2 (mg/kg)

Table : 5.16 Typical Composition of Fish and Shellfish (portion normally utilized)

Type	Protein (%)	Fat (%)	CHO (%)	Moisture (%)	Ash (%)
Fish:					
Sole	16.7	0.8	0	81.3	1.2
Rockfish	18.9	1.8	0	78.9	1.2
Cod	17.6	0.3	0	81.2	1.2
Catfish	17.5	3.1	0	78.0	1.3
Halibut	20.9	1.2	0	76.5	1.4
Menhaden	18.7	10.2	0	67.9	3.8
Anchovy	15-20	5-15	0	-	-
Herring	17.4	2-11	0	70.0	2.1
Salmon	19-22	13-15	0	64.0	1.4
Tuna	25.2	4.1	0	70.5	1.3
Shellfish:					
Clams(meat only)	14.0	1.9	1.3	80.8	2.0
Oysters	8-11	2.0	3-6	79-85	1.8
Crab	17.3	1.9	0.5	78.5	1.8
Shrimp	18.1	0.8	1.5	78.2	1.4

Source: U.S. Environmental Protection Agency. 1975.

Feed Name	Reference No.	Dry Matter (%)	Crude Fiber (%)	Digestibility Coefficient	Crude Protein (%)	Digestible Protein (%) Cattle	Digestible Protein (%) Sheep	Digestible Protein (%) Swine	Digestible Energy (Mcal/kg) Cattle	Digestible Energy (Mcal/kg) Sheep	Digestible Energy (Kcal/kg) Swine	Ash (%)	Ca (%)	P (%)	Vitamin A Equivalent (International units per gram)
					Dry Matter Basis										
Alfalfa, aerial part, fresh, mid-bloom	200185	24.2	27.7	45	20.4	15.9	15.2	-	2.69	2.53	-	9.9	2.01	0.29	-
Almond, hulls	400759	91.0	15.2	-	4.2	0.6	0.4	-	3.42	3.18	-	6.5	-	-	-
Almond, shells	107754	92.5	45.2	-	-	-	-	-	-	-	-	3.7	-	-	-
Apples, fruit, ensiled	200419	12.4	14.5	-	5.5	1.2	1.2	-	3.16	3.03	-	4.9	-	-	-
Apples, pulp, ensiled	200420	21.4	20.6	-	7.8	[illegible]	[illegible]	-	3.26	2.94	-	4.9	0.10	0.10	-
Artichoke, tubers, ensiled	200470	[illegible]	27.[illegible]	55	7.0	2.8	1.2	-	[illegible]	[illegible]	-	19.5	-	-	-
Asparagus, stem butts, dehydrates ground	100427	91.[illegible]	31.9	41	15.6	10.4	9.7	-	2.17	2.07	-	15.0	-	-	-
Avocado, seeds, extender unspecified ground	500451	91.4	19.7	[illegible]	[illegible]	-	9.0	-	2.22	2.52	-	19.9	-	-	-
Banana, aerial part, fresh	200493	16.0	20.7	[illegible]	6.4	[illegible]	[illegible]	-	2.44	2.86	-	13.1	-	-	-
Banana, skins, dehydrated ground	400425	88.0	9.6	[illegible]	[illegible]	[illegible]	2.6	-	2.61	2.92	24.60	10.5	-	-	-
Barley, flour by-products without hulls	400547	89.3	[illegible]	[illegible]	[illegible]	10.9	[illegible]	-	3.01	3.49	29.76	4.9	-	-	-
Barley, grain cooked	400524	85.7	7.9	-	11.2	6.7	7.5	7.5	3.50	3.57	34.38	2.6	-	-	-
Barley, pearl by-product	400549	89.6	11.9	19	14.7	11.0	11.9	11.6	3.33	3.05	32.80	5.7	0.05	0.46	[illegible]
Barley, brewers grains, dehydrated	500516	91.1	19.9	-	[illegible]	-	-	-	2.86	2.94	30.60	4.1	-	-	-
Barley, distillers grains, dehydrated	500519	92.0	11.0	-	[illegible]	-	-	-	3.05	3.12	32.45	2.0	-	-	-
Bean, cannery residue, fresh	200527	9.4	17.5	-	23.5	17.9	[illegible]	-	-	-	-	-	-	-	41.[illegible]
Bean, pods, fresh	200539	28.2	[illegible]	-	7.4	4.2	3.9	-	2.74	2.90	-	4.2	-	-	-
Beet, sugar, pulp, wet	200671	11.3	[illegible]	[illegible]	11.7	5.7	6.4	-	2.81	3.22	-	4.7	0.86	0.10	-
Broccoli, leaves, fresh	200882	[illegible]	[illegible]	-	28.8	22.5	[illegible]	-	-	-	-	-	-	-	559.[illegible]
Cabbage, aerial part, fresh	201045	9.6	10.5	[illegible]	[illegible]	15.6	17.9	-	[illegible]	3.75	-	10.3	0.64	0.75	17.[illegible]
Cacao, hulls	101051	90.0	17.5	-	15.9	10.6	10.7	-	-	-	-	6.5	-	-	-
Carob bean, gluten, fresh etiolated	501129	90.0	-	-	-	-	-	-	-	-	-	-	-	-	-
Carrot, aerial part, fresh	208871	15.0	18.1	-	17.1	9.0	9.2	-	3.29	3.37	-	15.0	1.94	0.19	-
Carrots, roots, fresh	201146	12.9	9.1	[illegible]	[illegible]	5.1	7.9	7.7	3.62	3.85	[illegible]	9.7	0.37	0.32	[illegible]
Cassava, roots	201150	32.4	4.6	57	3.6	-0.5	[illegible]	-	3.47	3.60	34.19	3.9	-	0.12	-
Cassava, meal	401152	[illegible]	3.9	-	2.9	[illegible]	0.0	-	3.50	3.81	35.44	[illegible]	-	[illegible]	-
Cassava, seeds, extender unspecified	401151	87.2	2.5	[illegible]	1.6	-2.4	[illegible]	-	3.72	3.82	37.87	2.2	-	-	-
Cassava, tapioca flour	401154	88.7	[illegible]	-	2.6	-1.5	[illegible]	[illegible]	[illegible]	3.27	41.26	2.4	-	-	-

Table : 5.18 United States Seafood Processing Solid Waste.
(Swanson etal., 1980)

Category	Average 1972-76 Landing (10^6 kg)	Product Yield (%)	Solid Waste (%)	Peak Season
Fish:	1850(1977)			
Bottom fish	238(1972)	20-40[1]	55-75	Summer
Catfish	72(1975)	63[2]	37	Fall to Spring
Halibut	10	90[3]	10	May to September
Menhaden and Anchovies	877:115	28-36[4]	15[5]	June to September
Salmon	105	62-68[6]	16-27	July to August
		65-80[2]	21-23	
Tuna	181	40-50[7]	49-59	Summer
Shellfish:	516(1977)			
Clams & Oysters	46:24[8]	10-15	82-90	Year round Fall to Winter
Crabs				
Blue	61	9-16	51	Spring
Dungeness	10	17-27	50-60	December to March
Alaska King	43	25-36	57	Aug. to September
Tanner	27	10-20	50-60	Janurary to May
Shrimp	171	12-20	65-85	Varies with location
		89[9]	15	

1 Filleting process; fish flesh operations may achieve higher yields.
2 Farm raised catfish processing
3 Fresh/forzen processing
4 Rendering process; both fish meal and fish oil are considered final products
5 Represents concentrated ;fish solubles which are commercially marketed
6 Canning process
7 Does not include red meat (8 to 10% of tuna) which is processed for pet food
8 Excluding shell weight, total harvested weight is 5 to 10 times this value

Table : 5.19 Comparison of Heavy Metal Content in Municipal Sludge versus Shrimp and Crab Wastes. (Swanson, etal., 1980)

Constituent	Municipal Sludge (mg/kg dry weight) Mean	Range	Shrimp and Crab Wastes (mg/kg dry weight)
Silver, Ag	225	0-960	1.1
Boron, B	430	200-1430	23-31
Barium, Ba	1460	0-3000	9-41
Cadmium, Cd	.87	0-1100	-
Cobalt, Co	350	0-800	0.5
Chromium, Cr	1800	22-30,000	1-27
Copper, Cu	1250	45-16,000	34-117
Mercury, Hg	7	0.1-89	1.3
Manganese, Mn	1190	100-8800	12-400+
Selemium, Se	26	10-180	5
Strontium, Sr	440	0-2230	190-200+
Zinc, Zn	3480	50-28,000	59-264

Table : 5.20 Range of Values from Literature on Composition of Cattle, Pig, and Poultry Manures, Adapted from Tunney (1977a).

	Dry Matter (%)	Nutreints (kg per 10 tonnes fresh manure) N	P	K	Mg
Cattle manure	4-23	24-65	4-18	20-58	2-6
Pig manure	5-25	16-68	6-21	17-36	3-7
Poultry manure	23-68	96-230	24-120	38-116	12-22

Table : 5.21 Estimated Production of Agricultural Waste By-Products in 1977.
(Owen, 1980)

	Dry Matter (million tonnes)											
	United Kingdom	Africa	North and Central America	South America	Asia	Europe	Oceania	U.S.S.R.	Developed	Developing	Centrally Planned	World
Crop wastes produced on the farm												
High dry matter materials												
Cereal Straws												
Wheat	4.4	[illegible]	55.7	[illegible]	31.8	[illegible]	5.7	78.2	119.2	72.1	177.7	728.6
Rye	-	-	0.7	0.2	0.7	11.5	-	7.2	4.7	0.9	14.7	24.2
Barley	5.2	2.6	17.3	[illegible]	[illegible]	55.5	2.4	44.3	57.9	17.3	[illegible]	147.1
Oats	0.7	0.1	12.9	0.6	2.1	12.7	0.9	15.6	22.7	1.1	20.9	44.6
Maize	-	44.5	[illegible]	52.2	[illegible]	24.7	0.7	15.7	249.5	101.6	112.4	594.5
Millet and sorghum	-	21.9	[illegible]	14.4	[illegible]	1.2	1.7	3.7	-	90.7	78.7	170.7
Rice, paddy	-	2.7	5.7	11.1	234.2	1.7	0.5	1.9	19.9	152.9	123.8	711.5
Cereal straws total	14.7	92.8	444.7	97.2	569.5	[illegible]	14.5	170.1	579.2	471.5	522.3	1577.2
Soyabean straw	-	0.1	[illegible]	11.9	12.4	0.4	0.1	0.4	40.4	12.4	12.1	65.9
Cotton wood	-	[illegible]	10.6	7.6	[illegible]	0.7	0.1	9.7	[illegible]	19.1	17.7	45.4
Sunflower seed stover	-	0.5	1.1	0.5	1.5	[illegible]	-	5.0	2.5	1.4	6.2	[illegible]
Rapeseed straw	0.1	-	1.5	0.1	[illegible]	[illegible]	-	-	-	-	2.0	[illegible]
Low dry matter materials												
Sugar cane tops	-	4.5	11.3	[illegible]	22.9	-	2.0	-	5.7	46.3	7.6	55.7
Sugar cane tops	1.8	1.0	2.5	[illegible]	2.2	13.9	-	9.7	17.2	1.9	14.9	[illegible]
Crop wastes produced in centralized processing plants												
High dry matter materials												
Oat hulls	0.1	-	2.2	[illegible]	0.4	2.1	0.2	2.7	7.1	[illegible]	3.5	7.5
Maize cobs	-	5.6	77.6	5.6	11.6	10.5	[illegible]	2.2	40.7	16.4	24.1	74.2
Rice husks	-	1.7	1.1	2.2	57.1	0.7	0.1	1.4	7.2	22.6	25.8	62.7
Groundnut hulls	-	1.8	0.7	0.2	1.7	-	-	-	0.3	2.1	0.5	3.0

Table : 5.22 **The Yield of Biomass of Different Organisms and Different Wastes.**
(Gray and Berry, 1980)

Substrate	Organisms	Reduction (%) C.O.D.	Reduction (%) B.O.D.	Yield Biomass (g/l)	Yield Substrate (%)	Batch Time (hr)
Coffee waste waters	*Verticillium sp.*[1]	70	-	3.4	31 C.O.D.	24
Cane Blackstrap molasses	*Verticillium sp.*[1]	-	-	3.4	47 CHO	24
Brewery spent grain liquor	*Aspergillus niger*[2]	-	96	13.0	57 T.S.	144
Acid brine	*Geotrichum Candidum*[3]	-	87	13.0	62 B.O.D.	96
Carob extract	*Aspergillus niger(M1)*[4]	-	-	20.0	45 T.S.	24
Carob extract	*Fusarium sp. (M4)*[4]	-	-	20.0	47 CHO	20
Cassava	*Aspergillus quaigatus*[5]	-	-	24.0	46 CHO	20
Potato starch	*Aspergillus oryzae*[1]	91	-	-	46.2 CHO	-
Acid brine	*Candida utilis*[8]	-	93	7.9	-	-
Whey	*Saccharomyce fragilis*[7]	84	-	24.0	55 lac	4

Substrate	Organisms	Reduction (%) C.O.D.	Reduction (%) B.O.D.	Yield Biomass (g/l)	Productivity (g/l.hr)	Yield Substrate (%)	Dilution Rate (1/hr)
Confectionery effluent	*Candida utilis*[10]	74	81	10.12	-	43 C.O.D.	0.3
Molasses	*Saccharomyces kloeckerianus*[11]	-	-	-	1.00	51.4 S	1.0
Corn waste (lab.)	*Trichoderma viride*[12]	96.2	99.2	1.9-2.1	-	50 B.O.D.	0.055
Corn waste	*Trichoderma viride*[12]	92.0	97.5	-	-	50 B.O.D.	0.04
Whey	*Saccharomyces*[13]	-	-	-	-	45-52 lac	0.125

Note : CHO - carbohydrate; T.S. - total sugars; lac - lactose; S-sucrose

1 Espinosa et al. 1977.
2 Hang et al. 1975.
3 Hang et al. 1974.
4 Imrie and Vlitos 1975.
5 Imrie and Righelato 1976.
6 Reade and Gregory 1975.
7 Worgan 1976.
8 Hang 1977a, b.
9 Wasserman 1960
10 Forage 1978
11 Meyrath 1975.
12 Church et al. 1972.
13 Bernstein et al. 1977.

6. GUIDELINES USED IN OTHER COUNTRIES

We have received large number of documents from number of countries stating the rules and guidelines followed regarding waste disposal, waste management, waste utilisation etc. We have also received documents in languages other than English. In this chapter guidelines followed in many countries are presented.

US ENVIRONMENTAL PROTECTION AGENCY

Objectives and National Policy

The objectives of this Act are to promote the protection of health, and the environment and to conserve valuable material and energy resources by -

1. providing technical and financial assistance to State and local governments and interstate agencies for the development of solid waste management plans (including resource recovery and resource conservation systems) which will promote improved solid waste management techniques (including more effective organizational arrangement) new and improved methods of collection, separation and recovery of solid waste, and the environmentally safe disposal of nonrecoverable residues;
2. providing training grants in occupation involving the design, operation, and maintenance of solid waste disposal systems;
3. prohibiting future open dumping on the land and requiring the conversion of existing open dumps to facilities which do not pose a danger to the environment or to health;

4. regulating the treatment, storage, transportation, and disposal of hazardous wastes which have adverse effects on health and the environment;
5. assuring that hazardous waste management practices are conducted in a manner which protects human health and the environment;
6. requiring that hazardous waste be properly managed in the first instance thereby reducing the need for corrective action at a future date;
7. minimizing the generation of hazardous waste and the land disposal of hazardous waste by encouraging process substitution, materials recovery, properly conducted recycling and reuse, and treatment;
8. establishing a viable Federal-State partnership to carry out the purposes of this Act and insuring that the Administrator will, in carrying out the provisions of subtitle C of this Act, give a high priority to assisting and cooperating with States in obtaining full authorization of State programs under subtitle C;
9. providing for the promulgation of guidelines of solid waste collection, transport, separation, recovery, and disposal practices and systems;
0. promoting a national research and development program for improved solid waste management and resource conservation techniques, more effective organization arrangements, and new and improved methods of collection, separation, and recovery and recycling of solid wastes and environmentally safe disposal of nonrecoverable resources;

11. promoting the demonstration, construction, and application of solid waste management, resource recovery, and resource conservation systems which preserve and enhance the quality of air, water and land resources; and

12. establishing a cooperative effort among the Federal State and local governments and private enterprise in order to recover valuable materials and energy from solid waste.

Solid Waste Management Information and Guidelines

Within one year of enactment of this section, and from time to time thereafter, the Administrator shall, in cooperation with appropriate Federal, State, municipal and intermunicipal agencies, and in consultation with other interested persons, and after public hearings, develop and publish suggested guidelines for solid waste management. Such suggested guidelines shall -

1. provide a technical and economic description of the level of performance that can be attained by various available solid waste management practices (including operating practices) which provide for the protection of public health and the environment;
2. not later than two years after the enactment of this section, describe levels of performance including appropriate methods, and degrees of control, that provide at a minimum for (A) protection of public health ;and welfare; (B) protection of the quality of ground waters and surface waters from leachates; (C) protection of the quality of surface waters from runoff through compliance with effluent limitations under the Federal Water Pollution Control Act, as amended; (D)

protection of ambient air quality through compliance with new source performance standards or requirements of air quality implementation plans under the Clean Air Act, as amended; (E) disease and vector control; (F) safety; and (G) esthetics; and

3. provide minimum criteria to be used by the States to define those solid waste management practices which constitute the open dumping of solid waste or hazardous waste and are to be prohibited under subtitle D of this Act.

Where appropriate, such suggested guidelines also shall include minimum information for use in deciding the adequate location, design, and construction of facilities associated with solid waste management practices, including the consideration of regional, geo-graphic, demographic, and climatic factors.

The Trade Effluent Regulation, 1976 lay down the following standards for trade effluents discharged into watercourses or public sewers.

Table : 6.1 (units in mg/l or otherwise stated)

Item of Analysis	Public Sewer	Watercourse	Controlled* Watercourses
Temperature (°C)	45	45	45
Colour (LU)	-	7	7
pH value	6-9	6-9	6-9
BOD_5 at 20°C	400	50	20
COD	600	100	50
TSS	400	50	30
TDS	3000	2000	1000
Chloride (as Cl)	1000	600	400
Sulphate (as SO_4)	1000	500	200
Sulphide (as S)	1	0.2	0.2
Cyanide (as CN)	2	0.1	0.1

Detergent (LAS as methylene blue active substances)	30	15	5
Oil & Grease	60	10	5
Arsenic	5	1	0.05
Barium	10	5	5
Tin	10	10	5
Iron	50	20	1
Beryllium	5	0.5	0.5
Boron	5	5	0.5
Manganese	10	5	0.5
Phenolic Compounds (as phenol)	0.5	0.2	Nil
Cadmium**	1	0.1	0.01
Chromium**(trivalen & hexavalent)	5	1	0.05
Copper**	5	0.1	0.1
Lead**	5	0.1	0.1
Mercury**	0.5	0.05	0.001
Nickel**	10	1	0.1
Selenium**	10	0.5	0.01
Silver**	5	0.1	0.1
Zinc**	10	1	0.5
Metal in Total**	10	1	0.5
Chlorine	-	1	1
Phosphate (as PO_4)	-	5	2
Calcium	-	200	150
Magnesium	-	200	150
Nitrate (as NO_3)	-	-	20

A waste is considered toxic if the EPA prescribed procedure (0.5 acetic acid, at pH 5, for 24 hrs). Extraction Procedure, yields on extract with Constituents exceeding the following levels:

Table 6.2

Contaminant	Maximum Concentration milligrams per litre
Arsenic	5.0
Barium	100
Cadmium	1.0
Chromium	5.0
Lead	5.0
Mercury	0.2

Selenium	1.0
Silver	5.0
Endrin	0.02
Lindane	0.4
Methoxychlor	10.0
Toxaphene	0.5
2,4D (2,4 Dichlorophenoxyacetic acid)	10.0
2,4,5 TP Silvex (2, 4, 5 Trichloro phenoxypropionic acid)	1.0

Leaching Test - Recommended Acceptance Criteria for Suitability of Industrial Wastes for Landfill Disposal.

Table 6.3

Contaminant	Maximum Concentration (Milligram per litre)	Source
Arsenic	5	(1), (2)
Barium	100	(1), (2)
Cadmium	1	(1), (2)
Chromium	5	(1), (2)
Copper	100	(2)
Cyanide (total)	10	(3)
Fluoride	150	(3)
Iron	100	(2)
Lead	5	(1), (2)
Manganese	50	(2)
Mercury	0.2	(1)
Phenolic compounds (as phenol)	0.2	(2)
Selenium	1	(1), (2)
Silver	5	(1)
Zinc	100	(2)

(1) U.S. Code of Federal Regulations (CFR), title 40, chapter 1, Part 261 "Identification and Listing of Hazardous Waste"

(2) Victorian E.P.A. Industrial Waste Strategy Management Paper WMI/86, "Disposal of Immobilised Hazardous Waste", 1986.

(3) NSW SPCC Chemical Control Order or Anluminium Smelter Waste, February, 1986.

Many areas of the United States currently face serious problems in safely and effectively managing the garbage they generate. As a nation, we are generating more trash than ever before. At the same time, we are finding that there are limits to traditional trash management practices. As the generation of municipal solid waste (MSW) continues to increase, the capacity to handle it is decreasing. Many landfills and combustors have closed, and new disposal facilities are often difficult to site. As a result, many communities face hard choices when weighing trash management options. Some communities end up paying premium prices to transport their garbage long distances to available facilities. Others try to site facilities nearby and encounter intense public conflict. Of course, not all communities face such problems; numerous communities have found creative solutions through source reduction and recycling programs. Still, for much of the nation, the generation and management of garbage presents problems that require our focused attention.

Identifying the components of the waste stream is an important step toward solving the problems associated with the generation and management of garbage. MSW characterizations, which analyze the quantity and composition of the municipal solid waste stream, involve estimating how much MSW is generated, recycled, combusted, and disposed of in landfills. By determining the make up of the waste stream, waste characterization also provide valuable data for setting waste management goals, tracking progress toward those goals, and supporting planning at the national, state, and local levels. For example, waste

characterizations can be used to highlight opportunities for source reduction and recycling and provide information on any special management issues that should be considered.

Municipal solid waste includes wastes such as durable goods, nondurable goods, containers and packaging, food wastes, yard wastes, and miscellaneous inorganic wastes from residential, commercial, institutional and industrial sources. Examples of waste from these categories include appliances, newspapers, clothing, food scraps, boxes, disposable tableware, office and classroom paper, wood pallets, and cafeteria wastes. MSW does not include wastes from other sources, such as municipal sludges, combustion ash, and industrial nonhazardous process wastes that might also be disposed of in municipal waste landfills or incinerators.

Generation refers to the amount (weight, volume, or percentage of the overall waste stream) of materials and products as they enter the waste stream and before materials recovery, composting or combustion (incineration) takes place.

Recovery refers to materials removed from the waste stream for the purpose of recycling and/or composting. Recovery does not automatically equal recycling and composting, however. For example, if markets for recovered materials are not available, the materials that were separated from the waste stream for recycling may simply be stored or, in some cases, sent to a landfill or incinerator.

Discards include the municipal solid waste remaining after recovery for recycling and composting. These discards are usually combusted or disposed of in landfills, although some MSW is littered, stored, or disposed of on site, particularly in rural areas.2

Guidelines for Land Application

The best agricultural use of AFBC residue is as a lime source on cropland, pastures, or reclaimed surface mines. It is attractive to agriculture and the power industry because it attacks soil acidity, which is the major recurring soil fertility problem in humid regions, and it provides a means of using the maximum amount of AFBC residue that currently would be environmentally safe. Applying AFBC residue to cropland as an example of calculations is given in Figure 6.1.

The following area few items to consider when applying AFBC residue or any other material to croplands:

1. Avoid applying residue when cropland is too wet to support the weight of the application equipment. This will prevent soil compaction problems.
2. Avoid spreading residue where it may be washed into streams or sinkholes by runoff from sudden heavy rains.
3. Avoid allowing animals to graze on pastures limed with AFBC residue until there has been sufficient rain to wash the residue from the herbage. Although there is little danger to the animal from directly ingesting heavy metals from the residue, the CaO and $Ca(OH)_2$ in the residue can be caustic to the gastrointestinal tracts of grazing animals.
4. Apply the residue evenly over the distribution area.

5. Make sure the spreading equipment s calibrated and is in good working order.

6. Apply residues so that there is sufficient time for soil reaction before planting the crop.

The seventh task is to monitor the pH and heavy metals in soils treated with AFBC residue.

Task 1	Soil and crop information
	Soil type: Silt loam Crop : Alfalfa Lime requirement: 1.7 tons/acre
Decision 1	Lime is required for this crop. Proceed to next task.
Task 2	AFBC residue analyses
	Lime content 60% $CaCO_3$ Cd 0.05 ppm Zn 55 ppm Cu 15 ppm Ni 21 ppm Pb 3.2 ppm Cr 15 ppm B 110 ppm
Decision 2	$CaCO_3$ is greater than 30%. Proceed to next step.
Task 3	Calculate AFBC residue application rate.
	Rate = Lime requirement/(lime content/100) = 1.7 tons/acre/(60/100) = 2.8 tons/acre

Task 4 Calculate heavy metal and B loadings.

Loading = element content x rate x 0.002[1]

	ppm		Tons/acre		Pounds/acre
Cd	0.5	x	2.8	x	0.002 = 0.003
Zn	55	x	2.8	x	0.002 = .310
Cu	15	x	2.8	x	0.002 = .084
Ni	21	x	2.8	x	0.002 = .118
Pb	3.2	x	2.8	x	0.002 = .018
Cr	15	x	2.8	x	0.002 = .084
B	110	x	2.8	x	0.002 = .620

[1]0.002 is a conversion factor used when the concentration of the element is expressed in ppm, ug/g, or mg/kg.

Task 5 Calculate total heavy metal loadings (pounds per acre); previous loading was 0.

	current and total loading	maximum loading[1]
Cd	0.003	4.5
Zn	.310	300
Cu	.084	150
Ni	.118	60
Pb	.018	600
Cr	.084	600

[1]Values for silt loam soil

Decision 3 Total cumulative heavy metal loadings below maximum and current B loading below 2 pounds per acre. Proceed with application.

Task 6 Apply AFBC residue according to local cropping practices.

Task 7 Monitor pH and heavy metals in the soils with appropriate soil tests.

Decision 4 If there is no rapid increase in heavy metal above normal levels in the soil, go to decision 5; discontinue AFBC residue applications.

Decision 5 If soil needs more lime, return to task 2; or go to task 7.

Figure 6.1 : Examples of calculations for applying AFBC residue to cropland.

The fifth decision step is to determine whether additional residue can be applied to the distribution area. If soil tests indicate no additional lime is needed, go to task 7. If the soil requires more lime, return to task 2.

Table 6.4 : Toxicity Characteristics constituents and Regulatory levels

Constituent	Regulatory Level (mg/l)
Arsenic	5.0
Barium	100.0
Benzene	0.5
Cadmium	1.0
Carbon tetrachloride	0.5
Chlordane	0.03
Chlorobenzene	100.0
Chloroform	6.0
Chromium	5.0
o-Cresol	200.0
m-Cresol	200.0
p-Cresol	200.0
Cresol	200.0
2,4-D	10.0
1,4-Dichlorobenzene	7.5
1,2-Dichloroethane	0.5
1,1-Dichloroethylene	0.7
2,4-Dinitrotoluene	0.13
Endrin	0.02
Heptachlor (and its hydroxide)	0.008
Hexachlrobenzene	0.13
Hexachloro-1, 3-butadiene	0.5
Hexachloroethane	3.0
Lead	5.0
Lindane	0.4
Mercury	0.2
Methoxychlore	10.0
Methyl ethyl ketone	200.0
Nitrobenzene	2.0
Pentachlorophenol	100.0
Pyridine	5.0
Tetrachloroethylene	0.7
Toxaphene	0.5
Trchloroethylene	0.5
2,4,5-Trichlorophenol	400.0
2,4,6-Trichlorophenol	2.0
2,4,5-TO (Silvex)	1.0
Vinyl chloride	0.2

SOLID WASTE AND NIGHTSOIL COLLECTION FEES

Table 6.5

Source of fee	Collection volume	Fees
House or building	20 litre/day or less	40 Baht/month
	40 litre/day or less	60 Baht/month
	60 litre/day or less	100 Baht/month
	80 litre/day or less	150 Baht/month
	100 litre/day or less	200 Baht/month
	200 litre/day or less	300 Baht/month
	300 litre/day or less	500 Baht/month
	400 litre/day or less	700 Baht/month
	500 litre/day or less	900 Baht/month
	When the collection volume per day exceeds the contracted collection volume for each 10 litre of excess or fraction thereof.	
Market, factory and other places	1 cu.m./day or less	2000 Baht/month
	More than 1 cu.m./day: for each 1 cu.m. of excess or fraction thereof.	2000 Baht/month
Periodic Collection	1 cu.m./day or less	150 Baht/time
	More than 1 cu.m./time: for each 1 cu.m. of excess or fraction thereof	150 Baht/time
Nightsoil Collection	For each cu.m. or fraction of first cu.m. thereof.	250 Baht/time
	When the collection volume exceeds 1 cu.m. the fraction less than 0.5 cu.m. thereof. (for fraction exceeds 0.5 cu.m., fee is equal to 1 cu.m.)	

Table 6.6 : Expired or unusable solvents

No.	Solvents	Chemical formular
2.1	Chloromethane or Methylchloride	CH_3Cl
2.2	Monochlorobenzene or Chlorobenzene	C_6H_5Cl
2.3	Dichloromethane or Methylene Chloride	CH_2Cl_2
2.4	1,2-Dichloroethylene or Acetylene dichloride	ClCHCHCl
2.5	Trichloromethane or Chloroform	$CHCl_3$
2.6	1,1,1-Trichloroethane or Methylchloroform	CH_3CCl_3

2.7	1,1,2-Trichloroethane or Vinyl Trichloride	Cl_2CCCl_2
2.8	1,1,2-Trichloroethylene	$ClCHCCl_2$
2.9	1,1,2,2-Tetrachloroethylene or Perchloroethylene	Cl_2CCCl_2
2.10	1,1,2,2-Tetrachloroethane or Acetylene Tetrachloride	$Cl_2CHCHCl_2$
2.11	Ethyl Chloride	C_2H_5Cl
2.12	2-Butenal or Crotonaldehyde	$CH_3CHCHCHO$
2.13	Carbon Disulfide	CS_2
2.14	1-Chloro-2,3-Epoxypropane or Epichlorohydrin	CH_2OCHCH_2Cl
2.15	3,5-dimethylphenol or Xylenol	$(CH_3)_2C_6H_3OH$
2.16	Hydroxy Benzene or Phenol	C_6H_5OH
2.17	Nitrobenzene or Nitrobenzol	$C_6H_5NO_2$
2.18	1,1-Oxybis(2-Chloroethane)or Dichloroethyl Ether	$O(CH_2CH_2Cl)_2$
2.19	Pentanchloroethane or Pentalin	$CHCl_2CCl_3$
2.20	Methyl Alcohol or Methanol	CH_3OH

Table 6.7: Solid waste or unusable material from specific industries

No.	Solid waste or unusable material	Type of factory as defined in Notification of the Ministry of Industry (No.1) B.E. 2512 and No. 7 B.E. 2520, issued under Factory Act B.E. 2512.
3.1	Sludge from NaCl solution preparation and waste water treatment system.	Sodium hydroxide industry, or industry category number 42 and industry category number 10(2) specific sodium hydroxide manufacture by using mercury cell
3.2	Residue of toxic chemicals as defined in Toxic Substance Act B.E. 2510	insecticide industry or industry category number 43.
3.3	Wastewater sludge	paint industry or industry category number 45 (1)
3.4	Dust from air pollution control systems and wastewater sludge	lead smelting industry or industry category number 60 and battery industry category number 74(1)
3.5	Expired or unusable electronic parts	electronic industry or industry category number 72
3.6	Wastewater sludge, expired or unusable chemical solutions and residues from electroplating tank	electroplating industry
3.7	Wastewater sludge	explosive industry or industry category number 99
3.8	Exhaust tube or under - standard tube	fluorescent tube industry or industry category number 74(1)

3.9	Wastewater sludge, under - standard battery, and dust from air pollution control systems	battery industry or industry category number 74(5)
3.10	Paint residue	vehicle industry or industry category number 77(1), (2) and from motorcycle, tricycle, bicycle industry of industry category number 78(1) and (2).

Table 6.8

No.	Solid waste or unusable material	Detoxification method
1.	Sludge containing mercury	Mix sludge with Na_2S in order to obtain HgS and then solidify by mixing with cement. To increase efficiency, additives should be added.
2.	Solid waste from fluorescent tube manufacture containing mercury	Mix grinded residue with Na_2S and then solidify with cement. To increase efficiency, additives should be added.
3.	Sludge or dust containing heavy metals e.g. cadmium, chromium, lead or manganese	Mix sludge or dust with lime or sodium hydroxide until pH of solution are about 11 then set in dry. Sludge or dust containing cadmium must be solidified with cement.
4.	Sludge or unusable materials containing pesticides, insecticide, or fungicides	Add with lime or sodium hydroxide solution until toxicity is over.

Table 6.9

Parameters	Maximum allowance (mg/litre)
Arsenic (As)	0.05
Cadmium (Cd)	0.01
Chromium(Cr)	0.05
Lead(Pb)	0.05
Mercury(Hg)	0.001
Nickel(Ni)	0.05
Manganese(Mn)	0.30
Copper(Cu)	1.00
Zinc(Zn)	5.00

Table 6.10 : Effluent Standards: Toxic and other Deleterious Substance (Maximum Limits for the Protection of Public Health)

Parameter	Unit	Protected waters Category I (Class AA & SA)		Protected waters Category II (Class A, B & SB)		Inland waters Class C		Marine waters Class SC		Marine waters Class SD	
		OEI	NPI	OEI	NPI	OEI	NPI	OEI	NPI	OEI	NPI
Arsenic	mg/L	(B)	(B)	0.2	0.1	0.5	0.2	1.0	0.5	1.0	0.5
Cadmium	mg/L	(B)	(B)	0.05	0.02	0.1	0.05	0.2	0.1	0.5	0.2
Chromium (hexavalent)	mg/L	(B)	(B)	0.1	0.05	0.2	0.1	0.5	0.2	1.0	0.5
Cyanide	mg/L	(B)	(B)	0.2	0.1	0.3	0.2	0.5	0.2	-	-
Lead	mg/L	(B)	(B)	0.2	0.1	0.5	0.3	1.0	0.5	-	-
Mercury(tot)	mg/L	(B)	(B)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.01
PCB	mg/L	(B)	(B)	0.003	0.003	0.003	0.003	0.003	0.003	-	-
Formaldehyde	mg/L	(B)	(B)	2.0	1.0	0.2	1.0	2.0	1.0	-	-

Note:

a) The effluent standards apply to industrial manufacturing plants and municipal sewage treatment plants discharging more than thirty (30) cu.m. per day. Except as otherwise indicated, all limiting values in Table are maximum values that shall not be exceeded.

b) Discharge of sewage and/or trade effluents are prohibited or not allowed.

Table 6.11: **Effluent standards: Conventional and other pollutants in protected waters category I & II and in Inland waters class C*.**

Parameter	Unit	Protected Waters Category I OEI	Protected Waters Category I NPI	Protected Waters Category II OEI	Protected Waters Category II NPI	Inland Waters Class C OEI	Inland Waters Class C NPI
Color	PCU	(B)	(B)	150	100	200[c]	150[c]
Temperature (max. rise in deg.Celsius in REW)	°C rise	(B)	(B)	3	3	3	3
pH (range)		(B)	(B)	6-9	6-9	6-9	6-9
COD	mg/L	(B)	(B)	100	60	150	100
Settleable Solids (1-Hour)	mL/L	(B)	(B)	0.3	0.3	0.5	0.5
5-Day 20°C BOD	mg/L	(B)	(B)	50	30	80	50
Total Suspended Solids	mg/L	(B)	(B)	70	50	90	70
Total Dissolved Solids	mg/L	(B)	(B)	1200	1000	1500	1000
Surfactants (MBAS)	mg/L	(B)	(B)				
Oil/Grease (Petroleum Ether Extract)	mg/L	(B)	(B)	5.0	5.0	10.0	5.0
Phenolic Substances as Phenols	mg/L	(B)	(B)	0.1	0.005	0.5[a]	0.1[a]
Total Coliforms	MPN/100mL	(B)	(B)	5000	3000	15000	10000

Table 6.12: Effluent Standards : Conventional and Other Pollutants in Inland Waters Class D, Coastal Waters Class SC and SD and Other Coastal Waters not yet classified.

Parameters	Unit	Inland Waters		Coastal Waters (class SC)		Class SD & other Coastal Waters Not Classified	
		OEI	NPI	OEI	NPI	OEI	NPI
Color	PCU	-	-	(C)	(C)	(C)	(C)
Temperature (max. rise in deg.Celsius in RBW)	°C rise	3	3	3	3	3	3
pH (range)		5-9	6-9	6-9	6-9	5-9	5-9
COD	mg/L	250	[illegible]	250	200	300	200
5-Day 20°C BOD	mg/L	150[D]	120	120[D]	100	150[D]	120
Total Suspended Solids	mg/L	200	150	200	150	(F)	(F)
Total Dissolved Solids	mg/L	2000[H]	1500[H]	-	-	-	-
Surfactants (MBAS)	mg/L	-	-	15	10	-	-
Oil/Grease(Petroleum Ether Extract)	mg/L	-	-	15	10	-	-
Phenolic Substances as Phenols	mg/L	-	-	1.0[I]	0.5[I]	5.0	1.0
Total Coliforms	MPN/100mL	(J)	(J)	-	-	-	-

Table 6.13: Interim effluent standards for BOD applicable to old or existing Industries producing strong industrial wastes (1990-1994)

Industry Classification Based on BOD of Raw waste-waters produced	Maximum Allowable Limits in mg/L*, according to Time Period and Receiving Body of Water			
	Effectivity date-Dec.31, 1991		Jan.1,1992-Dec.31,1994	
	Inland Waters (Class C&D)	Coastal Waters (Class SC&SD)	Inland Waters (Class C&D)	Coastal Waters (Class SC&SD)
1. Industries producing BOD within 3000 to 10000 mg/L	320 or 95% removal	650 or 95% removal	200 or 95% removal	320 or 95% removal
2. Industries producing BOD within 10000 to 30000 mg/L	1000 or 95% removal	2000 or 95% removal	600 or 95% removal	1000 or 95% removal
3. Industries producing more than 30000 mg/L	1500 or 95% removal	3000 or 95% removal	900 or 95% removal	1500 or 95% removal

Note:

1. Use either the numerical limit or percentage removal whichever is lower (or whichever is more strict).
2. Starting January 1, 1995, the applicable effluent requirements for old or existing ar indicated in Table.

Table 6.14: Effluent Standards for New* Industries Producing Strong Wastes upon Effectivity of these Regulations, and for All Industries Producing Strong Wastes starting January 1, 1995.

Industry Classification Based on BOD of Raw Wastewater	Maximum Allowable Limits in mg/L Based on Receiving Body of Water	
	Inland Waters	Coastal Waters
1. Industries producing within 3000 to 10000 mg BOD/L	100 or 98% removal	200 or 97% removal
2. Industries producing within 10000 to 30000 mg BOD/L	200 or 99% removal	600 or 97% removal
3. Industries producing more than 30000 mg BOD/L	300 or 99% removal	900 or 97% removal

Note: * including old or existing industries producing strong waste whose wastewater treatment plants are still to be constructed.

EUROPEAN COMMUNITY (E.E.C.)

Council Directive on the protection of environment, and in particular of the soil when sewage sludge is used in Agriculture.

Table 6.15 : **Limit Values for Concentrations of Heavy Metals in Soil**
(mg/kg of dry matter in a representative sample, of soil with a pH of 6 to 7)

Parameters	Limit values (1)
Cadmium	1 to 3
Copper (2)	50 to 140
Nickel (2)	30 to 75
Lead	50 to 300
Zinc (2)	150 to 300
Mercury	1 to 1.5
Chromium (3)	-

(1) Member States may permit the limit values they fix to be exceeded in the case of the use of sludge on land which at the time of notification of this directive is dedicated to the disposal of sludge but on which commercial food crops are being grown exclusively for animal consumption. Member States must inform the Commission of the number and type of sites concerned. They must also seek to ensure that there is no resulting hazard to human health or the environment.

(2) Member States may permit the limit values they fix to be exceeded in respect of these parameters on soil with a pH consistently higher than 7. The maximum authorized concentrations of these heavy metals must in no case exceed those values by more than 50%. Member States must also seek to ensure that there is no resulting hazard to human health or the environment and in particular to ground water.

(3) It is not possible at this stage to fix limit values for chromium. The Council will fix these limit values later on the basis of proposals to be submitted by the Commission, within one year following notification of this Directive.

Table 6.16

LIMIT VALUES FOR HEAVY-METAL CONCENTRATIONS IN SLUDGE FOR USE IN AGRICULTURE
(mg/kg of dry matter)

Parameters	Limit values
Cadmium	20 to 40
Copper	1000 to 1750
Nickel	300 to 400
Lead	750 to 1200
Zinc	2500 to 4000
Mercury	16 to 25
Chromium (1)	–

(1) It is not possible at this stage to fix limit values for chromium. The Council will fix these limit values later on the basis of proposals to be submitted by the Commission within one year following notification of this Directive.

Table 6.17

LIMIT VALUES FOR AMOUNTS OF HEAVY METALS WHICH MAY BE ADDED ANNUALLY TO AGRICULTURAL LAND, BASED ON A 10-YEAR AVERAGE
(kg/ha/yr)

Parameters	Limit values
Cadmium	0.15
Copper	12
Nickel	3
Lead	15
Zinc	30
Mercury	0.1
Chromium (1)	-

(1) Member States may permit these limit values to be exceeded in the case of the sue of sludge on land which at the time of notification of this Directive is dedicated to the disposal of sludge but on which commercial food crops are being grown exclusively for animal consumption. Member States must inform the Commission of the number and type of sites concerned. They must also ensure that there is no resulting hazard to human health or the environment.

(2) It is not possible at this stage to fix limit values for chromium. The Council will fix these limit values later on the basis of proposals to be submitted by the Commission within one year following notification of this Directive.

SLUDGE ANALYSIS

1. As a rule, sludge must be analyzed at least every six months. Where changes occur in the characteristics of the waste water being treated, the frequency of the analyses must be increased. If the results of the analyses do not vary significantly over a full year, the sludge must be analyzed at least every 12 months.

2. In the case of sludge from the treatment plants referred to in Article 11, if a sludge analysis has not been carried out in the 12 months preceding the implementation, in each Member State, of this Directive, an analysis must be carried out within 12 months of such implementation, or, where appropriate, within six months of the decision authorizing the use in agriculture of sludge from such a plant. Member State shall decide on the frequency of further analyses on the basis of of the results of the initial analysis, any changes in the nature of treated waste water and any other relevant factors.

3. Subject to the provisions, analysis should cover the following parameters:
   - dry matter, organic matter
   - pH
   - nitrogen and phosphorus
   - cadmium, copper, nickel, lea. zinc, mercury, chromium.

4. In the case of copper, zinc and chromium, where it has been shown, to the satisfaction of the competent authority of the Member State concerned that they are either not present at all

or present only in negligible quantities in the waste water treated by the sewage plant, Member State shall decide on the frequency of the analyses to be carried out.

CANADA

Table 6.18 : Minimum Acceptable Ratios of Nitrogen and Phosphorus to Metals and Boron in Sludge

	Cd	Cr	Cu	Hg	Ni	Pb	Zn	B
Nitrogen (Organic + Nitrate + Ammonium)	1,500	20	15	3,000	100	20	10	300
Or[1]								
Phosphorus(Total)	600	8	6	1,100	40	8	4	120

[1] Sludge is acceptable if either the nitrogen or phosphorus criteria are met. Spiking sludges with nitrogen or phosphorus to achieve these ratios is not permitted.

Table 6.19 : Classification of Sites on the Basis of Soil Characteristics. Topography and Geology.

	Acceptable[1]			Not Acceptable
	Class 1 Sites	Class 2 Sites	Class 3 Sites	Class 4 Sites
pH	≥6.5	≥6.5	≥6.5	<6.5
Texture	CL,Sicl, SiL, Si,SiC L,SCL,SC	C,HC	LS,SL	sand and grave
Slope[2]	0.2	2.5	5.9	9
Depth to Potable Aquifer (m)	>5	3.5	2.3	<2

[1] A site falls into the lowest class represented by any characteristics.
[2] A site with a pH less than 6.5, which would otherwise be classed 1 or 2 may be upgraded by liming to pH 6.5 or higher.

* Restriction of sludge application rates based on slope considerations apply only when surface application methods are employed. Slope criteria can be relaxed if sludge is applied by subsurface injection.

Table 6.20 : Maximum Addition of Sludge Solids and Sludge-Borne Nitrogen for Each Site Class and Sludge Type-Single Application.

	Solids Applications Rate[1]			Total Nitrogen Application Rate			Available Nitrogen ((NH_4+NO_3)-N) Application Rate for Surface Spreadings[2]		
	t/ha-dry weight basis			kg/ha			kg/ha		
Sludge Type	Class 1 Sites	Class 2 Sites	Class3 Sites	Class 1 Sites	Class 2 Sites	Class3 Sites	Class 1 Sites	Class 2 Sites	Class 3 Sites
Digested	25	20	10	900	700	400	450	350	[illegible]
Waste Stabilization Pond	10	9	5	900	600	300	400	300	150
Undigested[3]	5	4	2.5	600	500	200	300	250	[illegible]

[1]. For surface application a maximum hydraulic loading rate of 100m^3/ha/day is imposed for sludges containing less than 5% [illegible] Allowable solids and nitrogen rates for such sludges may be achieved by making several incremental additions with the soil cult[illegible] between each addition. There is no hydraulic loading rate restriction on sub-surface injection.

[2]. For sub-surface injection the maximum available nitrogen application rate is 200 kg/ha on Class 1 and 2 Sites and 150 kg/ha on [illegible] 3 Sites.

[3]. Undigested sludge must have been stored for a minimum of 6 months, have a pH of greater than 12 or have a volatile solids conte[illegible] less than 60% of the total weight of solids.

Table 6.21 : Maximum Cumulative Additions of Sludge-Borne Elements to Soils* (kg/ha)

	B**	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Class 1 Sites	10	1.5	100	200	0.5	25	100	300
Class 2 Sites	7.5	1.1	75	150	0.4	19	75	200
Class 3 Sites	5	0.8	50	100	0.2	12	50	150

* Not more than one-third of the cumulative loading may be applied in a single application.

** Boron levels are hot-water soluble. Levels for other elements are based on total quantities.

ADDITIONAL APPLICATION RESTRICTIONS

1. Method of Application

Acceptable methods include INJECTION and SURFACE APPLICATION. If surface application is employed it must be followed, as soon as is possible, by tillage.

2. Minimum Acceptable Distances From Specified Features

The following minimum distances are required: It may often be in the interest of the municipality and haulage contractor to exceed these to ensure public acceptance of sludge spreading programs.

Table 6.22

Feature	Minimum Distance m	Preferred Distance m
Rivers[a],Canals[a],Creeks[a], Intermittent Drainage Courses,Lakes,Sloughs,Dugouts	30*	50
Water Wells	20	50
Areas Zoned Residential or Devoted to Urban use	500*	800
Occupied Dwellings	60*	100
Road Allowance	10	20
Public Building Perimeters	10	30
Public Buildings	60*	100
School Yard Boundaries (School in Session)	200*	500
School Yard Boundaries (School not in Session)	20*	20
Cemeteries, Playgrounds, Parks, Compounds	200*	500

[1] Greater separation distances may be required based on local topographic and climatic conditions.

[2] Distances required are from the major break in slope.
[3] Distance can be reduced by 67% if sludge s sub-surface injected.

3. Seasonal

APPLICATION is permitted during spring, summer and fall and is not permitted on ground which is ice-covered, snow-covered or frozen.

4. Land Use

Acceptable Crops[1]	Unacceptable
Forages[2]	Root Crops
Oil Seed Crops	Vegetable & Fruit Crops
Small Grains[3]	Tobacco Crops
Commercial Sod	Dairy Pasture Land
Trees	

[1] Permission to apply sludge on lands intended for growth of crops not listed may be given.
[2] Direct grazing of sludge treated forage lands is not recommended for a period of 3 years immediately following application.
[3] Wheat is preferable to barley. Oats are not recommended in the first two growing seasons following sludge treatment.

Table 6.23 : Maximum Tolerable Levels of Dietary Minerals for Domestic Livestock in Comparison with Levels in Forages (Chaney, 1982)

Element	Soil Plant Barrier	Levels in Plant Foliage* (mg kg dry foliage) Normal	Phytotoxic	Maximum Level Chronically Tolerated (mg/kg dry diet) Cattle	Sheep	Swine	Chicken
As, inorganic	yes	0.01 - 1	3 - 10	50	50	50	50
B	yes	7 - 7.5	75	150	(150)	(150)	(150)
Cd**	Fails	0.01 - 1	5 - 700	0.5	0.5	0.5	0.5
Cr^{3+} oxides	yes	0.1 - 1	20	(3000)	(3000)	(3000)	3000
Co	Fails?	0.01 - 0.3	25 - 100	10	10	10	10

Cu	yes	3 - 20	25 - 40	100	25	250	300
F	yes?	1 - 5	-	40	60	150	200
Fe	yes	30 - 300	-	1000	500	3000	1000
Mn	?	15 - 150	400 - 2000	1000	1000	400	2000
Mo	Fails	0.1 - 3.0	100 10	10	20	100	
Ni	yes	0.1 - 5	50 - 100	50	(50)	(100)	(300)
Pb**	yes	2 - 5	-	30	30	30	30
Se	Fails	0.1 - 2	100 (2)	(2)	2	2	
V	yes?	0.1 - 1	10	50	50	(10)	10
Zn	yes	15 - 150	500 - 1500	500	300	1000	300

* Continuous long-term feeding of minerals at the maximum tolerable levels may have adverse effects. Interactions between metals were not studied and may increase tolerance above the values shown where diets contain increased concentrations of more than one metal. Concentrations in parentheses were not available for the species listed and were extrapolated from data for similar species.

**Maximum tolerable dietary concentrations based on residues in animal products used as human food rather than on toxicities to the species listed.

Table 6.24 : Maximum permissible levels of heavy metals in sludges acceptable for use on Agricultural lands in several countries (Webber *et al.* 1983)

	Permissible Level (mg/kg dry weight)											
Country*	Cd	Zn	Cu	Ni	Pb	Cr	Mn	Mo	Co	As	Se	Hg
Belgium	10	2000	500	100	300	500	500	-	20	[illegible]	25	10
Canada**	20	1850	-	180	500	-	-	20	150	75	14	5
Denmark	8	-	-	30	400	-	-	-	-	-	-	[illegible]
Finland	30	5000	3000	500	1200	1000	3000	-	100	-	-	25
France	20	3000	1000	200	800	1000	-	-	20	-	100	10
Germany	20	3000	1200	200	1200	1200	-	-	-	-	-	25
Netherlands	10	2000	600	100	500	500	-	-	-	[illegible]	-	10
Norway	10	3000	1500	100	300	200	500	-	20	-	-	[illegible]
Sweden	15	10000	3000	500	300	1000	-	-	50	-	-	8
Switzerland	30	1000	1000	200	1000	1000	-	20	100	-	-	10

* United Kingdom: Sludge for public distribution should not contain more than 20 mg Cd/kg dry wt. Sludge applied to pasture land should not contain more than 3500 mgF/kg dry wt. and applied to pasture land, gardens and recreational areas should not contain more than 2000 mg Pb/kg dry wt.

United States: Sludge applied to fruit and vegetable crop land should not contain more than: Cd, 25; Pb, 1000; and polychlorinated biphenyls, 10 mg/kg dry wt.

** Values are for sludge and sludge-based commercial products containing ≤5% nitrogen (Standish, 1981).

Table 6.25 : Clean-up Guidelines for Soils

Parameter[2]	Criteria for Proposed Land Use[1/3]			
	Agricultural/Residential/Parkland[4]		Commercial/Industrial	
	Medium & Fine Textured Soils	Course Textured Soils[5]	Medium & Fine Textured Soils	Course Textured Soils[5]
pH (recommended range)	6-8	6-8	6-8	6-8
EC (mS/cm)[7]	2	2	4	4
SAR[8]	5	5	12	12
Arsenic	25	20	50	40
Cadmium	4[1a]	3[1a]	8[1a]	6[1a]
Chromium (VI)	10	8	10	8
Chromium (total)	1000	750	1000	750
Cobalt	50	40	100	80
Copper	200[1b]	150[1b]	300	225
Lead	500[1a]	375[1a]	1000[1a]	750[1a]
Mercury	1[1a]	0.8[1a]	2[1a]	1.5[1a]
Molybdenum	5[1b]	5[1b]	40	40
Nickel	200	150	200	150
Nitrogen (%)	0.5[9]	0.5[9]	0.5[9]	0.5[9]
Oil and Grease (%)	1[6]	1[6]	1[6]	1[6]
Selenium	2[1b]	2[1b]	10	10
Silver	25	20	50	40
Zinc	900	600	900	600

Notes:

[1] Clean-up guidelines recommended by the Phytotoxicology Section, Air Resources Branch, Ministry of the Environment. The guidelines are based primarily on phytotoxicity except for ([1a]) based on human health, and ([1b]) based on health of grazing animals.

[2] All units are in ppm (ug g⁻¹), dry weight, unless otherwise stated.

[3] For comparison with these guidelines, analyses for metal and metalloids must be conducted using an approved strong, mixed-acid digestion procedure. Contact the Laboratory Services Branch of MOE if in doubt about acceptable methods.

[4] Guidelines have been endorsed by the OMAF/MOE/MOH Sludge utilization committee.

[5] Defined as greater than 70% sand and less than 1% organic matter.

- Guidelines given is for fresh oil; for weathered oil (min. 2 yr. exposed on site), the guideline is 2%.

[7] EC = electrical conductivity (saturation extract).

- SAR = sodium adsorption ratio

- If nitrogen levels exceed the guidelines, the mineralization of the soils should be evaluated. Additions of nitrogen-based fertilizer may be counter-productive.

Table 6.26 : Quebec Water and Soil Contamination Indicators

	Soil mg/kg of dry matter (ppm)			Ground Water ug/L (ppb)		
	A	B	C	A	B	C
I - Heavy Metals & Elements						
Ag	2	20	40	5	50	200
As	10	30	50	5	50	100
Ba	200	500	2000	50	1000	1000
Cd	1.5	5	20	1	5	20
Co	15	50	300	10	50	200
Cr	75	250	800	15	40	500
Cu	50	100	500	25	500	1000
Hg	0.2	2	10	0.1	0.5	1
Mo	2	10	40	5	20	100
Ni	50	100	500	10	250	1000
Pb	50	200	600	10	50	100
Se	1	3	10	1	10	50
Sn	5	50	300	10	30	150
Zn	100	500	1500	50	5000	10000
II - Mineral Pollutants						
Br	20	50	300	100	500	2000
NO_2 (as N)				20	1000	-
NO_3 (as N)	-	-	-	10	10000	-
NH_4	-	-	-	200	500	1500
CN, free (total)	1	10	100	40	200	400
CN, complex (total)	1	50	500	40	200	400
F (total)	200	400	2000	300	150	4000
PO_4 (as P)	-	-	-	50	100	700
S (total)	500	1000	2000	-	-	-
Hydrogen Sulfide (H_2S)	-	-	-	10	50	500

III - Monocyclic Aromatic Hydrocarbons (MAH)						
Benzene	0.1	0.5	5	0.5	1	5
Ethylbenzene	0.1	5	50	0.5	50	150
Toluene	0.1	3	30	0.5	50	100
Styrene	0.1	5	50	0.5	40	120
Xylene (total)	0.1	5	50	0.5	20	60
Monochlorobenzene	0.1	1	10	0.1	2	5
Dichlrobensene (any one of)	0.1	1	10	0.1	2	5
IV - Phenolic Compounds						
Phenols	0.1	1	10	1	3	20
Chlorophenos (each)	0.1	0.5	5	1	2	5
Chlorophenos (total)	0.1	1.0	10	1	4	10
V - Polycyclinc Aromatic Hydrocarbons (PAH)						
Anthracene	0.1	10	100	0.2	7	30
Benzo (a) anthracene	0.1	1	10	0.1	0.2	1
Benzo (c) phenanthrene	0.1	1	10	0.1	·0.5	2
Benzo (a) pyrene	0.1	1	10	0.1	0.2	1
Chrysene	0.1	1	10	0.1	1.0	5
Dibenzo (a,h) anthracene	0.1	1	10	0.1	0.2	1
Dibenzo (a,h) pyrene	0.1	1	10	0.1	1.0	5
Dibenzo (a,i) pyrene	0.1	1	10	0.1	1	5
Dimethylbenz (a) anthracene	0.1	1	10	0.1	0.2	1
Fluoranthene	0.1	10	100	0.1	2.0	10
Fluorene	0.1	10	100	0.1	2	10
Benzo (b) fluoranthene	0.1	1	10	0.1	0.2	1
Benzo (j) fluoranthene	0.1	1	10	0.1	0.2	1
Benzo (k) fluoranthene	0.1	1	10	0.1	0.2	1
Indano (1,2,3,c,d) pyrene	0.1	1	10	0.1	1.0	5
Naphthalene	0.1	5	50	0.2	10	30
Phenanthrene	0.1	5	50	0.1	1	5
Pyrene	0.1	10	100	0.2	7	30
Total PAH	1.0	20	200	0.2	10	50
3-methylcholanthrene	0.1	1	10	0.1	0.2	1
acenaphthene	0.1	10	100	0.5	20	30
acenaphthylene	0.1	10	100	0.5	10	20
VI- Chlorinated Hydrocarbons						
Aliphatic chlorinated hydrocarons (each)	0.3	5	50	1	10	50
Aliphatic chlorinated hydrocarbons (total)	0.3	7	70	1	15	70
Chlorobenzene (each) except hexachlorobenzene	0.1	2	10	0.3	2	5
Chlorobenzene (total)	0.1	4	20	0.3	4	10
Hexachlorobenzene	0.1	2	10	0.1	0.5	2
Polychlorinated biphenyls (total)	0.1	1	10	0.1	0.2	1

VII - Pesticides						
Organochlorinated						
Aldrin & Dieldrin	-	-	-	0.05	0.7	2
Chlordane (total Isomers)	-	-	-	0.05	0.7	2
DDT	-	-	-	0.05	30	60
Endrin	-	-	-	0.05	0.2	0.5
Heptachlor epoxide	-	-	-	0.05	3	5
Lindane	-	-	-	0.05	4	10
Methoxychlor	-	-	-	0.05	100	200
Carbamates						
Carbaryl	-	-	-	0.05	70	150
Carbofuran	-	-	-	0.05	70	150
Chlorophenoxy carboxylic acid derivatives						
2,4-D	-	-	-	0.05	100	200
2,4,5-T	-	-	-	0.05	10	20
Organophosphorus						
Diazinon	-	-	-	0.05	14	30
Fenitrothion	-	-	-	0.05	7	20
Parathion	-	-	-	0.05	35	70
Parathion-methyl	-	-	-	0.05	7	20
Pyridylium derivatives						
Diquat	-	-	-	0.05	50	100
Paraquat	-	-	-	0.05	7	20
Trichloroacetates						
Picloram	-	-	-	0.05	1	2
Pesticides (total)	0.1	2.0	20	0.05	100	200
VIII - Other Pollutants						
Gasoline	100	150	800	1000	1500	3000
IX - Indicators						
Mineral Oils	100	1000	5000	100	1000	5000

FINLAND

Objectives by types of waste

The objectives for increased recycling of some of the most important types of waste are summarised below. Aside from these, the recycling of other kinds of waste will also be intensified along the lines indicated in this Decision-in-Principle and in the Waste Recycling Development Programme prepared by the Advisory Board for Waste Management.

1. Scrap metal

Scrap metal recycling shall be intensified by 1995 in the following ways:

- the collection of discarded large household appliances and equipment shall be increased by at least 6,000 tons a year
- the collection of metal scrap from agriculture shall be increased so that at least 50,000 tons of stored scrap will be collected, as well as at least 5,000 tons of the scrap accumulating annually.
- the collection of scrap vehicles and lead shall be increased.

2. Waste glass

The collection of waste glass shall be increased by 1995 at the rate of 3,000 tons a year by intensifying the collection of glass from consumers and certain large producers. The return bottle system shall be further improved.

3. Waste gypsum

An attempt shall be made to increase, through research and product development, the recycling of waste gypsum originating from the reduction of sulphur discharges in power stations and from the manufacturing of phosphoric acid.

4. **Waste paper and board**

Waste paper and board collection shall be increased by 1995 from 3,10,000 tons to 4,50,000 tons a year. An attempt will be made to increase industry's use of discarded household paper by 1995 by 1,00,000 - 1,20,000 tons a year.

5. **Textile waste**

The recycling of textile wastes from the textile and clothing industries and consumers shall by 1995 be increased by 5,000 tons a year by intensifying initial sorting and collection, and through financial support for product development and experimental activities.

6. **Rubber waste**

Large-scale scrap tyre recycling shall be resorted to by the end of the 1980s. The goal is for 10,000 - 12,000 tons of scrap tyres to be recovered every year.

7. **Manure**

The efficiency of recycling of agricultural manure shall be improved considerably. Activities associated with this shall initially be carried out on an experimental basis in Mikkeli Province, improvements will be attempted jointly by the Ministry of the Environment and the Ministry of Agriculture and Forestry.

8. **Waste oil**

The utilization of waste oil for raw material and energy purposes shall be increased by 1995 by 25,000 tons, i.e. to the level of 65,000 tons a year. In order to achieve this end, steps will be taken to stop illegal combustion of oil, and oil

collection will be intensified so that a hazardous waste treatment plant serving the entire country will arrange for collection. Lubricating oil will be subject to a surcharge from the beginning of 1987. The money accruing from this will go towards waste oil management and treatment.

9. Solid municipal wastes

The recycling of solid municipal wastes shall be promoted through activities applying to each type of waste and by intensifying the initial sorting and collection of wastes, by increasing education and the dissemination of information, and by supporting municipal waste recycling development, experiments, and investments.

Table 6.27 : An estimation of wastes by type and degree of utilization in 1983.

Type of Waste	Accumulation 1,000 t/a	Degree of utilization, %
Agriculture and forestry		
Wood harvesting	15,000	2
Straw	4,000	10-25
Manure	19,000	100 (50[1])
Mining and ore-concentration		
Mine and concentration plant wastes	11,000-15,000	10-30
Building		
Construction wastes	5,000-10,000	-
Sewage treatment plants		
Sewage sludge	1,100	50
Other activities		
Timber wastes	10,000	85
Metal industry slag and sediments	1,400	72
Iron and steel scrap	900	90
Other metals	110-120	90
Gypsum	850	1

Paper and cardboard	815	45
Ash	650	40-50
Glass	70	15
Textiles	25-30	20
Plastic	90-110	15
Rubber	40-45	5
Food industry wastes	280-300	95
Leavings of food	150	5-10
Hazardous wastes[2]		
Ferrous sulphate	280	20-25
Oil	70-80[3]	60-70
Solvents	11	35-40
Paints and glues	15	5
Acids	180-190	-
Alkalines	80-90	-
Heavy metals	33	1
Other hazardous wastes	2	-
Community wastes[4]	2,000-3,000	10-20
Total accumulation	70,000-80,000	

[1] Real soil-improvement effect
[2] Not necessarily hazardous waste as defined in the Waste Management Act
[3] As 100% oil
[4] Quantitative data mainly included in figures stated elsewhere

SWEDEN

The producer will be responsible for all waste originating from his commercial activities, including the cost of disposal and of developing new, clean and resource-efficient products.

A problem is posed by the large volumes of waste. They must be reduced. There must therefore be an increase in the recycling and reclaiming of materials from the waste.

The dangerous elements in waste must be reduced - waste must be clean from the start.

Technology and systems must be developed for environmentally sound treatment and ultimate disposal of waste that cannot be further recycled.

Satisfactory waste disposal can only be achieved through a gradual process in which the manufacturer, state, local authorities and consumers all assume their responsibility.

POLICY

The Swedish Government has during 1986-87 given the following guidelines for the future solid waste management in Sweden:

1. The quantity of waste should be reduced by measures taken on both the production side and the consumption side. This should be a basic and common community task. Also the producers have a responsibility for the protection of the environment.
2. Produced waste should be reused or recovered as far as it is practically and economically possible.
3. Waste that must be processed should be handled and disposed of in such a way that negative effects on the environment will be minimized in both the short and long term. Stringent environmental protection requirements must thus be established.
4. The handling of hazardous waste must be improved. Substances and products which, after being mixed with other types of waste, cause special damage to the environment should be handled separately.

5. There must not be any one-sided emphasis on a particular method of waste treatment, or a situation which forces one particular method to be adopted. Alternative methods should be developed, tested and tried.

In 1985 the Swedish Association of Public Cleansing and Solid Waste Management presented its views on waste management in the future in a report titled "Future Waste Treatment in Sweden - A Combination of Methods to Conserve Resources and Improve the Environment". In summary the following was stated:

The management of the Swedish waste mountain must be based, both now and in the future, on a combination of different methods, where the choice of method must put environmental protection first. There must not be any contradiction between the different methods: instead they should be regarded a scomplementing each other. Only in this way the waste problem can be solved in an optimal fashion. Large-scale and small-scale methods must go hand in hand and complement each other.

In the future it would then appear that emphasis within solid waste management should be placed on the following:

* Recovery of material in households and industries, involving direct action by residents and industries in cooperation with those responsible for waste collection.
* Improved and rationalized collection and transporting of different kind of wastes.
* Thermal treatment of waste with energy recovery (provided that the environmental consequences of emissions can be kept under control even in the future).

* Landfilling which always will be needed regardless of other methods utilized, for non-reclaimable materials, residual products from other treatment etc.
* Continued research and development on central mechanical separation and composting of waste. * Development of large-scale methods for production of biogas out of organic waste.
* Increased utilization of material and energy resources in industrial waste. The conservation of resources should chiefly take place in the industries themselves, by using low-waste technology and by internal recovery of the waste products.
* Improved collection and treatment of hazardous wastes from the industry.

The representatives of waste management in Sweden are trying to minimize the environmental effect of produced waste by means of far-reaching environment-protective measures and in order not to cause further damage. The causes of environmental disturbances are usually to be found far back in the chain - in production and consumption.

Categories

The following categories of waste are collected or brought to final treatment or disposal in the municipalities:

* Household Waste
* Industrial Waste, including Construction and Demolition Waste
* Hazardous Wastes
* Sewage Sludge
* Ashes and Slags from power plants

Trade waste is included in both household waste and industrial waste.

Not included in industrial waste are wastes from agriculture, forestry, mining, fishery etc. (all together approx. 65 Mtons/y). **Not** included in household waste are reused and recovered materials such as bottles, cans, newspapers and cardboard.

Average composition, Swedish **household waste**:

Table 6.28

Fraction	% of weight
Paper	35-45
Plastics	8-10
Garbage, garden waste	25-35
Textile, leather, rubber	2-4
Metals	2-4
Glass	6-8
Wood	1
Miscellaneous	6-8

Waste treatment and disposal in Sweden in 1987 (after source recovery; % of weight)

Table 6.29

Category	Land Application	Incineration	Separation/ Compost	Landfilling
Household waste		55%	10%	35%
Industrial waste		5%		95%
Sewage sludge	60%			40%

The table below shows the development during the 1980s and the potential concerning incinerated amounts and energy production.

Table 6.30

Year	Incinerated amounts of waste (Mton) Household	Industrial	Energy recovery (TWh) Total
1980	0.72	0.14	1.4
1983	0.91	0.17	2.3
1986	1.29	0.24	3.4
Potential	2.0-2.5	1.5-2.0	9-11

At present basic research efforts are primarily focused on:

* waste processing to obtain higher-quality waste fuel
* further optimization of the combustion process
* formation mechanisms concerning mercury compounds and chlorine aromates
* recycling and disposal of slag, fly ash and other residues

The Swedish Association of Public Cleansing and Solid Waste Management (RVF), in capacity as the solid waste management organisation in Sweden, is co-operating with universities, governmental agencies and private companies in different research and development projects. The "Waste Incineration Group", an executive committee within RVF, is conducting projects within smaller project groups. Some of the on-going projects include:

* Exposure of heavy metals and organic compounds to plant operating staff
* Experience from flue gas condensation facilities
* Experiences from incineration of industrial waste
* Improvements of the fluid-bed technology
* Combined heat and power production from waste
* Emission levels and removal technologies concerning SOx and NOx contents in flue gas
* Training courses for plant operating staff
* Utilization of waste incineration slag as road construction materials

Almost 100% or 2,0,000 - 2,50,000 tons, of the Swedish household waste is treated in central plants for separation and

composting. At present 12 plants are in operation. At present, about 6 Mt/year of the following categories of waste are landfilled:

Table 6.31

Category	Amount (Mtons/y)
Household waste	1.0
Industrial waste	4.0
Sewage sludge	0.4
Slags, Ashes	0.6

Sewage Sludge

The annual production of sewage sludge in Sweden is estimated to 0.25 Mt dry matter (approx. 30 kg per person and year). All citizens are connected to secondary wastewater treatment and about 80% also to a teritary treatment step (chemical recipitation with phosphorus removal).

All sludge is stabilized (mainly by anaerobic digestion) and mechanically dewatered (centrifugation, filter-pressing). Digested gas is burned and used for internal heating purposes (digester, buildings).

Digested and dewatered sludge is landfilled (40%) or used in agriculture (60%). A sludge application rate of 5 t dry matter per hectare during a 5-year period (1 t DM/ha an year) is recommended.

Guidelines for metal content in sludge utilized in agriculture are presented in the table below.

Table 6.32

Metal	Recommended value (ppm dry solids)
Cadmium (Cd)	4*
Mercury (Hg)	5
Nickel (Ni)	100
Chromium (Cr)	150
Lead (Pb)	200
Copper (Cu)	600**)
Zinc (Zn)	1500

*) Limit value **) Upto 1200 for

soils needling addition of Cu

Table 6.33 : Management of hazardous wastes in Sweden in 1980.

Method	
Incineration 20%	
Recycling/conversion	24%
Other use	2%
Landfill	40%
Sewerage	12%
Other methods	1%
Storage (management not yet solved)	1%
Manager	
Own management by generator	36%
(industries etc.)	10%
SAKAB	33%
Other disposal companies	21%
Municipalities	

A total of 2,50,000 m^3 of sludge (dry weight) is generated annually. 90 per cent of this is stabilized through aerobic or anaerobic digestion, or by lime treatment and 87 per cent is dewatered by mechanical methods. 41 per cent of the sludge is used on agricultural land, 11 per cent for other land applications and 48 per cent is disposed of in sanitary landfills.

Sewage sludge should be managed and utilized as a resource rather than handled as waste. This basic concept means that the sludge primarily has to be used as fertilizer in agriculture and secondarily be applied to other types of land. This also means that the content of certain heavy metals has to be limited. The following guidelines are set for agricultural uses.

Table 6.34

Compound	Permissible concentration (as mg/kg sludge, 97% dry weight)
Zinc	1,000 - 3,000
Copper	500 - 1,500
Lead	100 - 300
Chromium	50 - 200
Nickel	25 - 100
Cobalt	8 - 20
Cadmium	5 - 15
Mercury	4 - 8

The application rate should not exceed 1 metric tone sludge per ha and year or five tones per ha every five years.

Domestic waste

In Sweden some 2.5 million tones of waste (1980) are produced annually by the households. Each person generates on an average some 300 kg waste each year. Domestic waste consists of the following components:

Table 6.35

Type of waste	% by weight
Plastics	10
Paper (newspaper, magazines, pasteboard, cardboard, etc.)	30
Laminated cardboard, milk containers etc.	4
Heavily soiled paper, napkins, kitchen rolls	9
Animal and vegetable waste	26
Textiles, rubber, leather	3
Metals (iron 5% and non-iron 1%)	6
Glass	5
Miscellaneous	7

The annual quantity of waste from construction activities, shops, offices, etc. can be estimated at 3.5 million tones.

Tble 6.36

Treatment methods	thousand tones/year		
	1975	1980	1985 (prognosis)
Grinding, sorting	60	121	246
Grinding, sorting, composting	0	139	592
Incineration - no energy util	170	173	118
Incineration with energy util	600	774	1033
Deposition - no pretreatment	1620	1303	511
Total waste quantity (does not include sludge or night-soil)	2450	2520	2500

Ordinance relating to hazardous wastes is applicable to solid or fluid waste of the following types:

1. oil waste;
2. solvent agent waste;
3. paint, glue, or lacquer waste;
4. concentrated acid or alkaline waste;
5. surface treatment waste containing compounds of cadmium, copper, nickel, tin or zinc;
6. waste containing silver or zinc from the printing or photographic industry;
7. waste containing mercury;
8. waste containing cyanide;
9. waste containing PCB (polychorinated biphenyls)
10. waste containing pesticides

Remedial Action Criteria

* Legal and Financial Responsibility
  - Polluter pays principle
  - Consideration of public interest
    - x Permanent solutions
    - x Coordinated, multi-party solutions
  - Environmental Protection Act (1969)
    - -> mobile operations excepted
    - -> passive polluting exempted
  - Person engaged in a polluting activity
    - -> property owner exempted
  - Remediation of nuisances, even after cessation of activities
    - -> non-retroactive

- Reasonable balance between technical feasibility and economic considerations

Uncontrolled Hazardous Waste Sites

* Landfills, Dump Sites & Mine Waste

  result of "planned" activities

* Contaminated Soils & Groundwater

- Agricultural -> result of "planned" activities

  - Industrial -> result of mostly "unplanned" occurrences

  * Contaminated Sediments

    result of both "planned and permitted" activities as well as "unplanned" occurrences.

Remediation at Industrial Facilities

* Sawmills & Industrial Wood Preservation

  - PAH, CCA, PCP, BOD, Phenols ....

* Coal Gasification, Asphalt Works, etc.

  - PAH, CN, Pb, Phenols ......

* Electroplating

  - Zn, Cr, Cu, Ni, CN, TCE ......

* Electrotechnical Plants & Scrap Facilities

  - Ni, Cd, Hg, Pb, CN, PCB ....

* Tanneries

  - Cr, TOC

* Paper Mills

  - BOD, COD, Phenols, Hg, PCB, AOX, TOCl, Dioxins.....

Switzerland

Proprietors may not deliver sewage sludge unless its levels of heavy metals do not exceed the following standards:

Table 6.37

Heavy metal	Standards (grams per ton of dry natter
Lead (Pb)	1000
Cadmium (Cd)	30
Chromium (Cr)	1000
Cobalt (Co)	100
Coper (Cu)	1000
Molybedenum (Mo)	20
Nickel (Ni)	200
Mercury (Hg)	10
Zinc (Zn)	1000

When delivering sewage sludge for utilization proprietors shall submit a delivery note with the following data:

a. content of dry matter;

b. total nitrogen;

c. nitrogen available on short-term;

d. phosphorus;

e. heavy metals (overall assessment);

f. hygienic properties.

THE GUIDELINES OF SWISS WASTE MANAGEMENT

In 1986, the Federal Commission for Waste Management discussed the ways and means of the solution for the waste problem

in Switzerland and formulated goals and objectives in the Guidelines of Swiss Waste Management. The main goal is that man and his environment will not be harmed because of the procedures and consequences of waste disposal. Preventive measures must be taken to minimize impact on the population and environment. Thus, not only an individual treatment and reprocessing plant must meet conditions of environmental protection but also the entire waste disposal system. This goal can be achieved:

1) if waste disposal plants yield only two classes of material, i.e. reusable goods and material suitable for final storage.
2) if, in the course of waste treatment, environmentally dangerous materials are recovered in undiluted form and environmentally non-problematic materials form similar to earth's crust or soil.

The great demands upon an environmentally conforming waste management requires an uninterrupted control of generation and treatment of waste, which dictates that it must be disposed in its own country. Therefore, it is an acknowledged goal of Swiss environmental strategy to treat waste and to dispose it within the borders of Switzerland. However, Switzerland accepts the necessity of international trade with reusable materials: Switzerland exports metal-containing waste-products (i.e. lead accumulators) because of the lack of domestic industries capable of processing metal ores.

Waste should be processed and reused if it is ecologically, energetically, and economically feasible. Thus, **recycling** is desired when the environmental impact is greater because of disposal of waste and parallel new production than the impact of processing and reuse. Non-recyclable waste must be disposed of. Swiss Waste Management is based on two cornerstone:

- **Incineration** of biologically foreign organic materials (Xenobiotica) in suitable incinerators.
- **Final Storage** of inorganic materials in a chemically inert matrix in a mono-disposal-site.

The two cornerstones of waste management - incineration and final storage - are essentially relevant for special waste. Final storage of suitable materials will be done in mono-landfills to **prevent intermixing** of different substances and to **provide resources for future generations.** Emissions of materials fit for final storage are so insignificant during operation of mono-landfills and after its completion that they can be stored in mono-landfills without the need of any further treatment.

The Swiss guidelines of waste management stipulate to refrain from subsidies for waste disposal and suggest that private enterprise shall organize waste disposal according to its real costs and competitiveness. The reason of this policy is that resources are used most economically and with least impact when waste producers must bear the costs of disposal (principle of causer's responsibility). Thus, costs of disposal are an important motivation for the reduction of wastes and increase of recycling rate. Administration will only intervene if the private

sector can not find a suitable solution. However, with environmentally pertinent ordinances the authorities will ensure that disposal methods and systems correspond to the newest technology.

Table 6.38 : Annual quantities of special waste.

Groups	Quantity in tons per year (approx.) Composition	
	anorganic	organic
a. Anorganic toxic and aggressive liquids	34,000	
b. Anorganic sludge (dry weight)	11,000	
c. Anorganic solids and powders	40,000	
d. Batteries, accumulators, fluorescent lights	18,500	
e. Organic liquids, pastes and solids with high calorific value (used oil, solvents, etc.)		1,30,000
f. Liquids with water and hydrocarbons (emulsions)		68,000
g. Condensers and transformers contaminated with PCB. PCB (disposal of accumulated stock)	550	
h. Diverse (Toxic materials from spec. collections, contaminated packing material etc.)	ca. 5,000	
i. Polluted soils, sludge from gutters and rain water collectors	ca.75,000	
Total a) to h) approx.	1,09,000	1,98,000
Total a) to i) approx.	1,84,000	1,98,000

OTHER BUILDING MATERIALS

Waste fractions used for building materials which are produced from municipal waste by sorting or treatment processes other than incineration, shall contain no more than:

a. lead 500 mg/kg

b. cadmium 10 mg/kg

c. mercury 2 mg/kg

Table 6.39

Pollutant	Maximum level
Florine	20 mg/kg
Chlorine	1000 mg/kg
Bromine	20 mg/kg
Lead	20 mg/kg
Cadmium	10 mg/kg

The content of heavy metals shall not exceed the following levels:

Table 6.40

Element	mg/kg dry waste
Lead	500
Cadmium	20
Copper	500
Nickel	500
Mercury	2
Zinc	1000

Requirements regarding the eluate obtained in the laboratory

The quantities of pollutants in the eluate, to which water saturated with carbon dioxide is continually added, shall not exceed the following maximum:

Table 6.41

Aluminum	10	mg/l
Arsenic	0.1	mg/l
Barium	5	mg/l
Lead	1	mg/l
Cadmium	0.1	mg/l
Chromium-III	2	mg/l
Chromium-VI	0.1	mg/l
Cobalt	0.5	mg/l
Copper	0.5	mg/l
Nickel	2	mg/l
Mercury	0.01	mg/l
Silver	0.1	mg/l
Zinc	5	mg/l
Tin	2	mg/l
Ammonia/Ammonium	5	mg N/l
Cyanides[1)]	0.1	mg CN/l
Flurides[1)]	10	mg/l
Nitrites[1)]	1	mg l
Sulphites[1)]	1	mg/l
Sulphides[1)]	0.1	mg/l
Phosphates[1)]	10	mg P/l
Dissolved organic carbon (DOC)[1)]	50	mg C/l

Hydrocarbons[1]	5	mg/1
Lipophil, non-volatile, organic chlorine compounds[1]	0.05	mg C1/1
Chlorinated solvents[1]	0.1	mg C1/1
Organochlorine pestizides[1]	0.005	mg C1/1
pH-value[1]	6 -	11

The biochemical oxygen demand (BOD_5) of the eluate shall not exceed 10 mg O_2/1.

Table 6.42 Plastics

Pollutants	Maximum level
fluorine	20 mg/kg
Chlorine	200 mg/kg
Bromine	20 mg/kg
Lead	20 mg/kg
Cadmium	10 mg/kg

[1] with distilled water used as eluate agent

Zinc-plated articles

Manufacturers who plate articles must ensure that the cadmium content of the zinc applied does not exceed the following maximum levels:

Table 6.43

	Applicable from 1 July 1987	Applicable from 1 July 1989	Applicable from 1 July 1991
Maximum level of cadmium in milligrams per kilogram of zinc	1,000	500	250

NETHERLAND

The Dutch waste management policy is aimed at the decrease of the amount which has to be disposed of at landfills. In order of preference this decrease is effected through:

1. prevention of waste;
2. recycling of waste;
3. incineration of waste, if possible;
4. disposal of waste at landfills.

Disposal of waste at landfills is only allowed if it is not possible to recycle or to treat the waste in other ways. Measures need to be taken to minimize the environmental impact of disposal, because of possible high concentrations of hazardous substances. For this reason, stringent requirements are set for landfills. In the Netherlands the requirements for landfills are the so-called IMC-criteria. These criteria are:

1. Dispersion of soilthreatenting substances has to be prevented by isolating measure;
2. Disposal of soilthreatenting substances at landfills, has to be manageable, and must remain so even when the isolating measures fail;
3. The landfill, disposal activities and the effectiveness of the measures should be and remain controllable.

Information about the behaviour of the to be disposed waste in relation to the already disposed material, the isolation material and the manageability is needed to meet the IMC-criteria.

The manageability of a landfill is also a function of the concentrations and (bio-) chemical properties of the hazardous substances in the leachate. So together with the volume reduction of waste it is important to minimize the amount of leachate and the concentration of hazardous substances in the leachate. Volume reduction can be attained by incineration of organic waste. Incineration will produce energy and in general the residues (ash, slag) will have little or no biochemical activity. Simple treatment of the now inorganic residues will diminish the mobility of the hazardous substances as well as the physical/chemical reactivity. So in general incineration of organic waste is recommended before disposal at landfills.

Waste Acceptance Criteria for Landfills

Acceptance of waste at a landfill will be judged on:

1. the possibilities for recycling or other treatment (in view of value reduction);
2. health and safety aspects (labourhealth, hazards, damage, impact on the surrounding area);
3. environmental aspects;
4. ease of handling the disposed waste on the landfill.

For the prediction of the environmental aspects as well as for the information about the manageability of the landfill, criteria for the .compostion and leaching behaviour are very important. Currently, leaching behaviour plays a minor role in acceptance criteria.

Future Landfill Policy in the Netherlands

The Dutch waste management policy is aimed at the decrease of the amount of waste by ways of prevention, recycling and incineration of organic waste. As a result, future landfills will be designated only for hazardous waste or for inert waste. Landfills for non hazardous organic waste are not desired because of the fact that it is not possible to predict the behaviour of the landfill when organic material is present in the landfill, so that the manageability of the landfill can not be ensured.

Before implementing a prohibition for the disposal of organic wastes at landfills, sufficient capacity for processing these kinds of wastes should be realized. Until that time these wastes still have to be disposed of at landfills. Environmentally sound solutions must be sought. Because of the unpredictable behaviour of a landfill at which organic waste is disposed of, security rules have to be stringent. This is only possible by accepting only waste containing low concentrations of hazardous substances or by adapting the facilities at the landfill.

7. DISCUSSION

Utilization of the soil system for disposal and treatment of wastes has the potential for taking advantage of the soils unique physical, chemical, and biological processes. The natural soil system offers a dynamic media for not only absorbing waste but for treating and utilizing waste constituents. The challenge is clear - to effectively design waste application systems that optimize a soil's treatment potential.

The porous nature of soil can provide an ideal media for absorbing and transmitting liquid effluent. A tortuous flow path through soil variety of natural treatment processes. Purification occurs through physical filtration, chemical treatment through ion exchange and transformation, biological decomposition by a myriad of micro-organisms as well as nutrient uptake by plants.

Clearly the ultimate goal in utilizing the complex array of dynamic soil processes is the protection of health and the environment. Herein lies a distinct difference between approaches that address only disposal and those that place a major emphasis on treatment. Regulatory programs challenged with controlling on-site systems for health and water quality reasons must certainly place priority on the goal of adequate treatment.

Many factors influence persistence of waste in soil. Broadly properties which affect soil waste interaction could be soil moisture, organic matter, redox conditions soil acidity, soil temperature, sorption-desorption, mineral constituents, waste

combinations etc. Following table provides details of physical and chemical parameters of importance for the soil quality.

Table 7.1 : Physical and chemical parameters of importance for the soil quality

Physical parameters	Chemical parameters
General	Organic matter
Distribution of particle sizes	Humus
soil type	Organic compounds with small molecules
Soil profile	Minerals
Soil colour	Calcium carbonate
Bulk density	Oxides & hydroxides
Density of the solid phase	Clay minerals
Soil moisture economy	Anions
Level of groundwater	Cations (including heavy metals)
Porosity	pH
Moisture tension	Adsorption-desorption processes
Hydraulic conductivity	Precipitation-solution processes
	Redox potential
Soil atmosphere, Gas diffusion	
Thermal conductivity and heat capacity	
Mechanical soil density	
Groundwater	
Resistance of semi-permeable layers	
Hydraulic head	
Transmissibility	
Penetration depth	

Table 7.2 : **Biological soil parameters of importance for the soil quality**

Structural characteristics	Functional characteristics
1. Soil fauna	Dispersion of organic matter
Density	Formation of soil profile
Reproduction and growth	Bioturbation
Immigration and emigration	Homogenization
Predation	Litter fragmentation and formation
Aggregation	
Association	
Distribution of micro-, meso-. macro-fauna	
2. Terrestrial vegetation	
Subsoil parts, rooting, rhizosphere	
Biomass and production	
Rhizosphere activity	
Mycorrhiza	
Seed germination	
Superterrestrial parts	
Biomass and production	
Absorption and accumulation	
Description and analysis of vegetation	
3. Soil mocroflora	Degradation of xenobiotics
Composition of population	Cycles:
Biomass	Carbon cycle Sulphur cycle Nitrogen cycle Phosphate cycle

Pojasek designed detailed site selection criteria in respect of tolerance suitability for chemical waste disposal as presented in table below:

Table 7.3. Sample Technical Site Selection Criteria

Category	Site Characteristic	Tolerance Suitability for Chemical Waste Disposal: Favorable Conditions	Limited of Unfavorable Conditions	Considerations
Land				
Soils and Topography	Topographic Relief	Gently rolling terrain	Hilly, or near-steep slopes	
	Soils-composition, engineering and site development	Suitable soils for dike construction and liner development	Poor foundation soil, unsuitable dike material; liner soils must be imported	Limited conditions [illegible] likely to add to facility development costs
	Soils-slope, erodibility	Slopes [illegible] to limit erosion potential	Slopes greater than [illegible] resulting in a high erosion potential	The exact slope limit needs to be defined on a site-specific basis
	Soils-texture	Clay to silt or loam (very fine to medium grain sizes)	Fine sands to gravels (coarse grain sizes	
	Soils-agricultural uses	Soils with lesser agricultural value	Prime agricultural land	
	Subsoils-composition	Suitable soils for dikes, buildings and liner development	Poor foundation conditions, unsuitable for dike materials ; liner soils must be imported	Cost is an important factor in this consideration
	Subsoil-permeability	Silt soils with high clay content and with low permeability ([illegible] cm/sec or less)	Clean sands and gravels, with permeabilities greater than 10.15 cm/sec	Here it is assumed that natural protection of low permeability deposits are more favorable than higher-permeability [illegible]
	Subsoil-thickness	Thick deposits of low-permeability materials, few or no sand and gravel	Thin deposits of low-permeable materials underlain by large thickness of sand and gravel	Ideally, a site should be underlain by a good thickness of impermeable materials underlying sands gravels are

		lens, uncompacted thickness no less than 4 ft.		less favorable
Geology	Bedrock-depth	Bedrock covered by thick deposits of unconsolidated material	Bedrock at or near surface	
	Bedrock-subcropping formation	Shale or undisturbed, very fine grained sedimentary formation	Highly fractured limestone or dolomites; coarse-grained permeable sandstone	The limitations introduced by this factor are dependent on the composition and thickness of the overlying
	Bedrock-structural conditions	No major structural variations within an area	Areas of faulting, extreme fracturing or severe folding	
Water	Groundwater-unconsolidations	No connection with surficial or buried drift aquifers, low permeable materials to bedrock	Underlain by surficial and buried drift aquifers of local and/or regional significance	The limitations introduced by these factors are dependent on the composition and thickness of the unconsolidated material and are site-specific
	Groundwater-bedrock formations	Away from any recharge areas to major bedrock acquires no direct connection with a usable bedrock aquifer	On a major bedrock aquifer recharge area; direct connection between a drift and usable bedrock aquifer	Potential for polluting a usable aquifer is the primary concern here
Man-Oriented	Land Use forested	Areas where existing forests may serve as a buffer	Areas where significant amounts of existing forests may be removed are not as attractive	Significant removal of forests is an additional cost factor
	Land Use cultivated land	Minor removal of land from current cultivation	Areas were significant removal of prime agricultural land from cultivation is required	Significant removal of prime agricultural land from cultivation can be a local socioeconomic cost factor
	Land Use urban residential	Areas with little	Areas with high urban development	Proximity to residences is considered less favorable
	Land Use extractive	Areas of no or low ongoing activity	Areas currently being mined or actively used	Use of abandoned extractive areas is questionable and would require site specific investigation
	Land Use pasture	Areas that are currently prime pasture lands	Significant pasturieng activities	Extent of pasturing determined by site-specific investigation

	Land Use urban and nonresidential or mixed residential	Site-specific	Areas with minimal commercial, industrial or institutional development	These factors can be considered exclusionary (schools, hospitals, airports)
	Land Use parks, wildlife preserves, recreation areas	Very limited	Site location in any of these land types	All federal, state, regional, county and local parks, preserves, historical areas, etc., are considered here; this factor is considered very limited area for a chemical waste disposal facility
	Land Use transportation	Good-conditions (9 ton or better) roads in area, lower traffic volume, near railroad	Roads in poor conditions, high traffic volume, high-hazard roads	The absence of 9 ton roads is is not exclusionary; however, upgrading of lesser roads may be a costly alternative
	Land Use historical archaeological	Dependent on site-specific details	Areas with confirmed historical or archeological significance .	This area will require some interpretation since areas of possible archaeological significance have been designated; services of a professional archaeologist may be costly alternative
	Socioeconomic land availability	Land available for purchase; minimum amount of land owners involved	Land unavailable or must be acquired through legal means, numerous land owners involved	
	Location	Near the majority of the waste generators	Away from waste generators	Based on the waste generator-waste disposer relationship; this aspect can become matter of transportation economics
Natural Conditions	Environmental unique areas	Areas of typical ecosystems	Areas of unique ecological sensitivity, e.g., habitats of unique and or endangered or threatened species	Extremely site-specific
	Environmental public health	Area where construction and operation will not adversely affect public health	Areas where dust, noise, fire explosion may create a public health and or safety hazard	Protection of the public is is the primary consideration
Non-Development	Engineering Suitability electric	Adequate electric power is relatively available in site		The economics of electrical transmission are a consideration

	Engineering Suitability sewer	Site near interceptor sewer or wastewater treatment plant		Not required, but could be used to dispose of clarified effluent. This item becomes a matter of economics
Water	Surface Water water-bodies and watercourses	Limited	Placement of facility on or near	
	Surface Water-flood plants, floodways	Limited	Placement of facility on or near	
	Surface Water-wetlands	Limited	Areas of poor drainage or where ponding occurs; drainage areas requiring excessive engineered controls	Site drainage may be a major factor in preventing the unplanned spread of chemical wastes at the facility; sites with suitable natural drainage conditions will be more favorable than those requiring large amounts of engineering and associated costs
	Drainage-local watershed	Site location near a drainage divide where upstream surface area is small	Site location where upstream surface area is great and engineering precautions to handle runoff become costly	
Air	Ambient Air Quality (odor, dust)	Good dispersive characteristics are important if the facility generates a discharge to the atmosphere	Dispersion is not expected to be an important consideration for land disposal facilities	These site characteristics are facility-specific
Climatology				Site-and facility-specific

Land use pattern also plays a significant role in deciding specific waste application to specific soil type. Following table provides some information regarding sensitivity of crop to sludge applications.

Table 7.4 : Relative sensitivity of crops to sludge applications

Very Sensitive	Sensitive	Very Tolerant	Tolerant
Chard	mustard	cauliflower	corn
lettuce	kale	cucumber	sudangrass
redbeet	spinach	zucchini squash	smooth bromegrass
carrot	broccoli		'Merlin' red fescue
turnip	radish	flatpea	
peanut	tomato		
	marigold	oat	
ladino clover		orchardgrass	
alsike clover	zigzag, red, kura and crimson clover	Japanese bromegrass	
crownvetch	alfalfa	switchgrass	
'Arc' alfalfa	Korean lespedeza	red top	
whilte sweet clover	sericea lespedeza	buffelgrass	
yellow sweet clover	blue lupin	tall fescue	
	birdsfoot trefoil	red fescue	
weeping lovegrass	hairy vetch	Kentucky bluegrass	
Lehman lovegrass	soybean		
deertongue	snaphean		
	Timothy		
	colonial bengrass		
	perennial ryegrass		
	creeping hengrass		

* Sassafrass sandy loam amended with a highly stabilized and leached digested sludge containing 5300 mg Zn, 2400 mg Cu, 320 mg Ni, 390 mg Mn, and 23 mg Cd/kg dry sludge. Maximum cumulative recommended amounts of Zn and Cu are applied at 5% sludge.

Injured at 10% of a high metal sludge at pH 6.5 and at pH 5.5

Injured at 10% of a high metal sludge at pH 5.5, but not at pH 6.5

Injured at 25% high metal sludge at pH 5.5, but not at pH 6.5, and not at 10% sludge at pH 5.5 or 6.5.

Not injured even at 25% sludge, pH 5.5

Table 7.5 : Permeability classes for saturated soil (U.S. D.A. Soil Conservation Service, 1971)

Soil Permeability (cm/h)	Class	Textural Class* Probable
< 0.02	Very slow	Dense, compacted clay
0.02 - 0.1	slow	Clay, loam, clay
0.1 - 0.3	moderately slow	Clay loam to loam
0.3 - 1.0	moderate	Loam to sandy loam
1.0 - 3.0	moderately rapid	Loamy sand to sand
3.0 - 10	rapid	Coarse sand
more than 10	very rapid	Gravel

* May vary in individual cases because of differences in soil structure.

Table 7.6 : Approximate Numbers of Organisms commonly found in Surface Soils* (Martin and Focht, 1977)

Organisms	Estimated numbers/g
Bacteria	3 000 000 to 500 000 000
Actinomycetes	1 000 000 to 20 000 000
Fungi	5 000 to 900 000
Yeasts	1 000 to 100 000
Algae	1 000 to 500 000
Protozoa	1 000 to 500 000
Nematodes	50 to 200

* The figures for bacteria, actinomycetes, fungi, and yeasts are based on plate counts and refer to viable propogules grown on the plating media. In addition to these there are large numbers of slime molds (Myxomycetes), viruses or phages of bacteria, algae, fungi, insects, plants, arthropods, earthworms, mycoplasmas, and other organisms.

Table 7.7 : Genera of Hydrocarbon-Degrading Bacteria and Fungi Isolated from Soil

Bacteria	Fungi
Achromobacter	Acremonium
Acinetobacter	Aspergillus
Alcaligenes	Aureobasidium
Arthrobacter	Beauveria
Bacillus	Botrytis
Brevibacterium	Candida
Chromobacterius	Chrysosporium
Corynebacterium	Cladosporium
Cytophaga	Cochliobolus
erwinia	Cylindrocarpon
Flavobacterium	Debaryomyces
Micrococcus	Fusarium
Mycobacterium	Geotrichum
Nocardia	Gliocladium
Proteus	Graphium
Pseudomonas	Humicola
Sarcina	Monilia
Serratia	Mortierella
Spirillum	Paecilomyces
Streptomyces	Penicillium
Vibrio	Phoma
Zanthomonas	Rhodotorula
	Saccharomyces
	Scolecobasidium
	Sporobolomyces
	Sprotrichum
	Spicaria
	Tolypocladium
	Torulopsis
	Trichoderma
	Verticillium

Source : Bossert and Bartha 91984).

Table 7.8 : Organic Molecular Fragments Amenable to Microbial Transformations

Alcohols	Ketones
Aldehydes	Lactams
Alicyclic aliphatics	Lactones
Aliphatics (saturated)	Nitriles
Aliphatics (unsaturated)	Nitro compounds
Amides	Nitrosamines
Amines	Organoarsenicals
Aromatics (simple substituted)	Organomercurials
Aromatic heterocyclics	Organophosphorus compounds
Azides	Organosulfates
Carbarmates	Organotins
Carboxylic acids	Oximes
Condensed aromatics	Quaternary ammonium compounds
Dithiocarbamates	Sulfides
Ester	Sulfonic acids
Ethers	Thioamides
Glycosides	Thiol carbomates
Halides	Thiols
Heterocyclics	Ureas
Hydroxamic acids	
Hydroxyl amines	

Table 7.9 : Maximum permissible cumulative metal loadings to agricultural lands in several jurisdictions

	Permissible Cumulative Loading (kg/ha)												
Jurisdiction	Cd	Zn	Cu	Ni	Pb	Cr	Mn	Mo	Co	As	Se	Hg	B
Alberta[a]	0.8-1.5	150-300	100-200	12-25	50-100	50-100	-	-	-	-	-	0.2-0.5	5-10
British Columbia[b]	4	370	-	36	100	-	-	4	30	15	2.8	1.0	-
Ontario[c]	1.6	330	150	32	90	210	-	4	30	14	2.4	0.8	-
Canada[d]	4	370	-	36	100	-	-	4	30	15	2.8	1.0	-
Denmark	0.2	-	-	-	-	-	-	-	-	-	-	-	-
Finland	0.1	-	-	-	-	-	-	-	-	-	-	-	-
France	5.4	750	210	60	210	360	-	-	-	-	-	2.7	-
Germany	8.4	750	210	60	210	210	-	-	-	-	-	5.7	-
Netherlands	2.0	400	120	20	100	100	-	-	-	2	-	2.0	-

Norway	0.2	60	30	2	6	4	10	-	0.4	-	5	0.14	-
Sweden*	0.075	50	15	2.5	1.5	5	-	-	0.25	-	-	0.04	-
United Kingdom	5	560	280	70	1000	1000	-	4	-	10	5	2.0	4.5
United States	5-20	250-1000	125-500	50-200	500-2000	-	-	-	-	-	-	-	-

Sommers and Giordano (1984). Studied use of nitrogen from agricultural, industrial, and municipal wastes. They summerised total NPK concentrations in selected waste materials reported by different people as presented below:

Table 7.10 : Total N,P and K concentrations in selected waste materials.

	Concentration of			
Waste material	N	P	K	Reference
	%			
Solid or semisolid:				
Composted or shredded refuse	0.57-1.30	0.08-0.26	0.27-0.98	McCalla et al. 1977
Leather tankage	12.80	0.01	0.26	Sims & Boswell, 1980
Waste food fiber	2.00	0.01	0.10	King, 1979
Paper mill sludge	0.15-2.33	0.16-0.50	0.44-0.85	Dolar et al., 1972
Citric acid production wastes	0.51-4.13	0.06-029	0.01-0.19	King & Vick, 1978
Antibiotic production mycelium waste	3.29	0.71	0.34	Nelson & Sommers, 1979
Tomato processing wastes	2.33	0.29	0.28	Tima et al, 1980
Municipal sewage	<0.1-17.6	<0.10-14.30	0.02-2.64	Sommers, 1977
	mg/L			
Liquids:				
Municipal wastewater	16-37	7-13	14-33	Sommers & Sutton, 1980
Potato starch waste	420	52	590	de Haan et al., 1973
Whey	1500	500	1920	Watson et al., 1977
Antibiotic production broth	936	690	604	Nelson & Sommers, 1979
Vegetable and fruit processing wastes	19-318	4-91	-	Sommers & Sutton, 1980

Expressed on a dry-weight basis

Expressed on a wet-weight basis (commonly contain solids)

SOIL ANALYSIS
(From EEC Rules)

1. Whenever sludge other than sludge from the treatment plants referred to in Article 11 is used, Member States must first ensure that the heavy metal content of the soil does not exceed the limit values laid down in accordance with Annex. For this purpose, Member States shall decide what analyses to carry out, taking account of available scientific data on soil characteristics and homigeneity.

2. Member States shall decide on the frequency of further analyses, taking account of the metal content of the soil prior to the use of sludge, the quantity and composition of the sludge used and any other relevant factors.

3. Analysis should cover the following parameters:
   - pH
   - cadmium, copper, nickel, lead, zinc, mercury and chromium.

Conclusions

- Mechanisms controlling the transport process in soils are the basis of any land application system for disposal, utilization, and treatment of wastes.

- Pathways of the transport process most important to land application of wastes are adsorption/precipitation, volatilization, degradation and bioabsorption.

To design a land application system, it is essential that environmental constraints are indentified, principal waste limiting constituents are established and the rate of application and capacities of the site are calculated.

Site and waste specific cause-effect relationship are needed to calibrate rate coefficients of the transport process equation.

Soil detoxification is essential for preventing surface and subsurface water decontamination. While basic and applied research have been conducted and some pilot, and demonstration facilities have been operated, the full-scale development of soil detoxification methods and application is far from completion. There still remain unanswered questions regarding how to maximize the rate of the soil decontamination processes. The effect of physical, and chemical parameters such as mobility, structure, inhibition, solubility, volatility, viscosity and density of contaminants, and soil texture, moisture, organic carbon and nitrogen content, cation exchange capacity, and pH on the soil detoxification processes are not completely known. More research and field performance testing are needed for full-scale development of soil detoxification methods. More study needs to be done to develop microorganisms capable of completely destroying different classes of contaminants. Most of the previous soil detoxification studies have been conducted with a single contaminant. The finding of these studies might not be directly applicable to mixture of contaminants due to interaction between different contaminants, and physico-chemical properties.

Review of the literature has revealed that excavation and treatment methods are more develop than *in situ* treatment methods. However, wet chemical processes such as chemical oxidation, dechlorination, photolysis, hydrolysis, and scrubbing are not completely developed. More study is needed to identify chemical compounds required for dechlorination, oxidation, photolysis and hydrolysis of potential toxic contaminants and their mixtures. successful soil detoxification requires a continuous source of contaminated soil, viable technology and cost effective economics. Excavation and treatment methods are very costly relative to *in situ* treatment methods. However, these methods have the potential of physically removing toxic contaminants. Development of the mobile systems might overcome some of the mentioned difficulties.

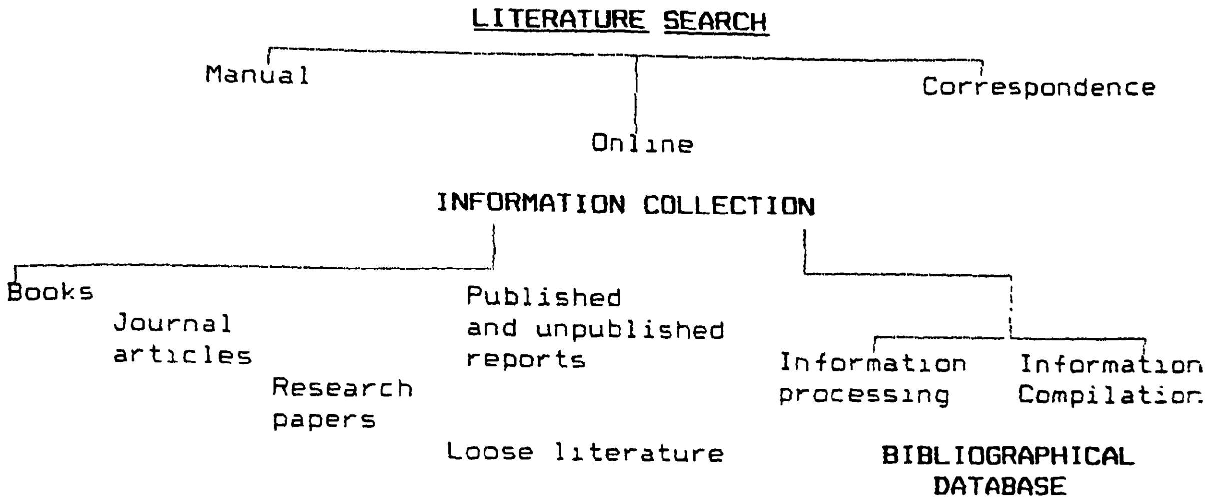
The manipulation of the soil environment. To simulate the ideal set of conditions is essential to maximize the inherent capacity of soil to degrade toxicants by chemical and biological mechanisms for microorganisms. Toxicity of pollutants, pH, ideal process temperature, soil carbon, nitrogen and oxygen content are the most important factors that affect the efficiency of these processes. In order to develop effective *in situ* treatment methods, more work is needed to investigate effect of the above mentioned factors. These methods re less costly and less destructive or environment. However, these methods require more time to detoxify and have a lower probability of destroying toxicants completely.

Table 7.9 provides details of guidelines regarding cumulative metal loadings to agricultural lands in various countries. These guidelines were developed after detailed study of various aspects of soil, waste and the chemistry of reactions between waste and soil. These aspects of soil are presented in Table 7.1 and 7.2. On the other side Table 7.3 gives proper site selection criteria for use of land as waste disposal facility. One also needs to study sensitivity of vegetation to waste application. Precisely study is required to explore soil-waste-groundwater-vegetation interaction. Table 7.10 presents fertility values of selected waste materials (NPK). Presently the information available in India regarding soil, waste and soil-waste-groundwater-vegetation interaction is not adequate enough to develop authentic guidelines for waste disposal in soils. There is need of:

a) detailed characterisation of soils all over the country (presently soil characterisation available in various soil survey reports does not provide details of all cations and anions present in soil, specially toxic metals).
b) detailed characterisation of wastes from different sources (industry, domestic, agriculture, etc.) is yet to be investigated.
c) soil-waste-groundwater-vegetation interaction studies are still in infancy stage.

This all does not allow to prepare the baseline information for development of national standards for waste disposal in soils.

8. DATABASE



A bibliographical database has been prepared on the subject - "Soil Quality Criteria for Disposal of Various Types of Wastes". The software package used in this connection is CDS/ISIS (Version 2.3) developed by UNESCO. This package has been designed specifically for the computerised management of structured databases, whose major component is text. The text is structured into data elements defined by the user. CDS/ISIS allows use :- 1) to define databases containing data elements, 2) to enter records into a defined database, 3) to modify records , 4) to search and retrieve records through a sophisticated search language, 5) to sort records in any desired sequence, 6) to display or print records as required, 7) to compile indexes and document lists.

All the materials collected have been bibliographically processed and recorded in the database. Each record contains the following components of information :-

1) Authorship (single, multiple or corporate body)
2) Title (Complete form)
3) Publication details
4) Name of document (source document/host document)
5) Type of the document (whether book or non-book)
6) Descriptor terms or Keywords
7) Abstracts
8) Any other specific information

The records stored in the database are in the nature of (i) complete books on the subject, (ii) journal articles giving details of the source documents, (iii) conference papers giving details about the conference, (iv) loose literature like bulletin, pamphlet, newsletters etc., giving information about their availability, (v) published and unpublished reports, (vi) chapters or sections of a book which are relevant to the subject field.

The bibliographical list enclosed in this report, contains the citations of references but does not give the keywords or abstracts. If details of keywords or abstracts are required, one may access the database, which is housed in the Documentation and Information Centre of Tata Energy Research Institute. Bibliographical details may be searched with the help of CDS/ISIS search language and the required information may be retrieved. Dissemination of such information will may also be possible through hardcopies, document lists or formatted bibliographies.

This database is not a one-time activity. It is regularly updated and new records entered so as to enable selective dissemination of information and compilation of bibliographies on demand. Information exchange is desirable and subject specialists, scientists and resource persons are always welcome to enhance this database by adding their valuable studies and reports.

9. MAJOR CONSTRAINTS

Following major constraints were faced during this work regarding information collection at both national and international level.

1. National

a. Responses and co-operation from different sources within India were not upto expectation.

b. Bibliographies, lists of citations and other forms of reference lists have been received but in most of the cases it was necessary to write back to concerned persons for full length papers/articles.

c. This is a nascent and a complex interdisciplinary subject, therefore, scientists and resource persons were not able to identify the research information immediately which was required on this topic. On the other side information is lacking in this area.

d. Even if information is available it lacks organisation. On the other hand, there is a dearth of sufficient infrastructural facilities viz. xeroxing, database, proper lending facilities in the form of inter library loan etc. at different centers and libraries. Consequently the entire information acquisition process gets delayed.

2. International

a. The operation at international level was followed as shown below:

```
TERI |----> Embassies/Highcommissions
      |
   ┌-|----> Addresses provided by embassies in respective
   |         countries                                   |
   |                                        |            |
   └-----> More relevant address provided by --┘         |
                              |                          |
                              └--------------------------┘
                                           |
                                      INFORMATION
```

This whole process is rather time consuming and postal services also take more time for overseas mail than inland.

b. We received a large number of documents but lots of information was in other languages than in English because most of the respondents sent information in their own languages e.g. French, Finnish, Thai, German etc.

c. We received national documents, government reports related to environmental protection, waste management etc. These documents were in the form of big volumes, books etc. Therefore, it was fairly time consuming to locate specific information on waste disposal in soils.

d. From some organisations we received bibliographies/citations. Therefore, it was needed to write back to relevant sources for full length papers/articles.

e. Subject specialist and professionals in this specific area had to be contacted for technical scientific details. Their availability, convenience and access to their specialisation appeared to be again a time-consuming process.

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